DECEMBER, 1945 ONE SHILLING & SIXPENCE

Plastics

DEALING WITH THE MANUFACTURE, USES AND POTENTIALITIES OF PLASTIC MATERIALS

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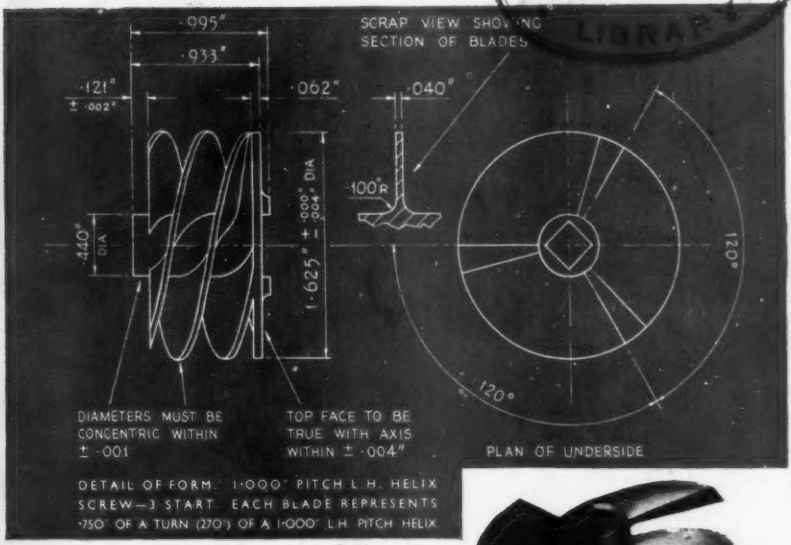
·995"
·933"
·121" ± ·002"
·062"
·040"
SCRAP VIEW SHOWING SECTION OF BLADES
100R
·440" DIA
1·625" +·000" −·004" DIA
120°
120°
DIAMETERS MUST BE CONCENTRIC WITHIN ± ·001
TOP FACE TO BE TRUE WITH AXIS WITHIN ± ·004"
PLAN OF UNDERSIDE
DETAIL OF FORM. 1·000" PITCH L.H. HELIX SCREW—3 START. EACH BLADE REPRESENTS ·750" OF A TURN (270°) OF A 1·000" L.H. PITCH HELIX

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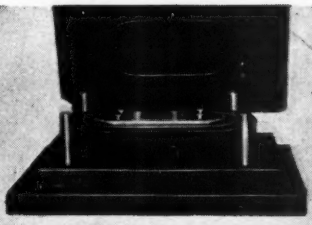

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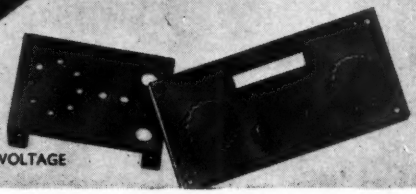

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Vol. IX. No. 103 DECEMBER, 1945

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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NOTICES

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EDITORIALS

Target—The German Plastics Industry

AS many of our readers are aware, groups of scientists of the Allied Nations—physicists, chemists and engineers—have been sent forth into the factories, universities and research institutions of defeated Germany to winkle out the secrets of many of her manufactures, those inventions and processes which she confidently hoped would sustain her economic life and military might so that her enemies might be crushed.

Twenty-six years ago the victorious Allies, in a much less scientific age, had been completely hoodwinked in a similar effort to probe the war efforts and manufacturing advances of Germany. To-day we are standing no nonsense from our enemies, and, indeed, possibly as a result, they appear to be unusually ingratiating and willing to disclose all. Nevertheless, we also understand that our scientists are aware of the possibility of the game known to the Secret Service as the double double-cross, and are careful in their acceptance of information.

As befits the present age, selected bands of scientists of our plastics industry have made it their business to examine certain "targets" in Germany, and have returned with much to tell.

While the full report has not yet been printed, nor yet completely compiled, one such visitor, Mr. Barclay B. Murdoch, O.B.E., B.Sc., A.R.I.C., M.I.Chem.E., returned and told his part of the tale to a large audience at a recent meeting of the Institute of the Plastics Industry.

His story was as fascinating as it was full of new facts and new ideas. It is obvious that, while a great many scientists and technologists had left the country before war was declared, a hard core of German brains remained to continue the work and to develop new methods and produce new materials.

Mr. Murdoch found many of the factories, for example, the I.G. factories at Ludwigshafen, badly knocked about. Indeed, services were almost non-existent. This is not surprising, as Ludwigshafen was so often on the visiting list of the Royal Air Force. Others which had moved east were not always badly damaged. The lecturer also told us of the frequent habit of making separate components in a number of different places, completing manufacture in yet another. It is difficult to tell why this apparently expensive method was adopted, but we believe it was not unknown before the war when secrecy even to other German concerns was desired.

Polyvinyl chloride was, as it had been before the war, in large production, and output of monomer had reached 4,500 tons per month. It had been obvious in pre-war days that this material was to be one of the important productions in Four-Year and subsequent plans for waterproof and leather replacement.

Mr. Murdoch related how, with the scarcity of fabrics, P.V.C. was widely used, and how it was modified or improved during the war. A flexible type was produced by incorporating a heat stabilizer and wax, followed by milling and stretching in two directions to orientate the molecules. He also mentioned a mechanical device (presumably controlled by electrical methods) for controlling 1/1000-in. thick material within ± 5 per cent. While this is extremely interesting, we await further details of what seems at first sight an unnecessary refinement for this class of material.

P.V.C. was quite widely employed in the manufacture of shoes for the German populace. Mr. Murdoch told us that much testing for the purpose had been carried out by sending wearers tramping around the country for thousands of

miles to prove its efficacy. If this is so, it would appear a typical German method of boosting the material for propaganda purposes. Efficient machines are available which can give sufficiently comparative results between P.V.C. and leather from the wearing point of view, even though actual walking conditions are not exactly simulated.

A surprising manufacture is that of chlorinated P.V.C. Presumably, chlorination of an already chlorinated material introduced new characteristics, such as increased flame-resistance and rot-proofing of fabrics.

Polyvinyl acetate formed the basis of an interesting belting. Milled with glycerine, it was built up layer by layer into a $\frac{3}{8}$-in. thick sheet, and then immersed in 50 per cent. phosphoric acid. It is claimed that the resultant belting lasted four times longer than leather.

Surgeons will be intrigued to hear that P.V.A. was also used as a lung tissue to heal perforations produced by wounds. The P.V.A. becomes part of the tissue and does not remain merely a foreign body embedded in the lung tissue.

Of other thermoplastics, Mr. Murdoch said that 500 tons of polystyrene were produced each month, and that a continuous polymerization process had been introduced. A flexible type was made by heat treatment and stretching.

It was also interesting to hear that surface hardening of poly-methylmethacrylate had not been accomplished.

In the thermosetting resin field, a new method of producing resin/wood flour plastics was described. It consists of introducing moisture into the mix, when it is milled and steam blown at 170 degrees C., then dried and ground. It is claimed that moulding powders are made with one quarter the normal labour cost.

The lecturer also reported the presence of 5,000-ton presses at the works of Dynamit A.G., which had been installed for the production of the so-called " people's car." Some 35,000 tons of urea glue were produced each year for the manufacture of plywood, etc.

Mr. Murdoch confessed that his notes gave by no means a complete picture of what all the groups saw. If this is so, then the final report will indeed be worth waiting for.

Silicone Resins

SOME six months ago we gave some information in these pages regarding the silicone resins, news of which had been slowly filtering into this country from the United States.

In October, Dr. Shalor L. Bass, of the Dow-Corning Corporation, visited this country and gave us the first-hand story of their characteristics and illustrated it with many interesting examples at a joint meeting of the Society of Chemical Industry (Plastics Section) and the I.E.E. (Radio Section). Doubtless we must point to the Dow-Corning Corporation, that combination of great chemical and glass organizations, as the home of the new resins. It is, therefore, all the more pleasing to hear from Dr. Bass's lips of the honour paid in U.S.A. to that famous English chemist, Professor F. S. Kipping, of Nottingham University, whose researches from 1899 onwards on organo-silicon derivatives laid the foundations of all the work carried out by Dow-Corning. We were also delighted to hear that Dr. Bass paid a visit to Professor Kipping during his stay.

These compounds, which are now in large-scale production in the U.S.A., not only create a new section of the resin-making industry, but open up possibilities generally, especially in the electrical field, which have, until now, been merely the hopeful dreams of the physicists. At long last the really high-temperature-resisting resins have been made. As for their general characteristics, the reader may refer to Mr. Penn's notes in our June issue.

An example by Dr. Bass of what this means to the electrical industry was that of a motor built by Westinghouse, using silicone resin as insulation. After running successfully at 100 degrees C., it was given an overload test at 300 degrees C. in the windings. As this produced no bad results, it was run for 45 mins. at 500

degrees C. After a humidity test, it was still in good condition, so it was reimpregnated and run for a life test at 250 degrees C. This was continued for 3,370 hours without breakdown.

Insulation, Dr. Bass indicated, would not in future be the greatest of designers' problems, and, without doubt, it means that a 10 h.p. motor now weighing 400 lb. could be built half that weight.

It is, therefore, with considerable admiration and pleasure that we congratulate the two American concerns on a production that not only cuts a new path in our own industry, but makes possible great advances in electrical spheres.

It was said that the present high price of silicones (£1 per lb. has been mentioned) will prevent their general use. In our opinion, at this figure they may prove the cheapest of all resins.

The World is Not Flat

MANY years ago Rudyard Kipling wrote what we believe to be his funniest story—of a Village that Voted the Earth was Flat, and of the tidal wave of mirth and scorn in which the village was drowned.

We seem to hear an echo of this story down the passage of the years in a strange rumour that one man has proved, to his own satisfaction if nobody else's, that the use of atomic energy for industrial purposes is quite impossible. Not, mark you, "too far in the future to matter," but definitely and simply, "quite impossible." Strange words these in this year of scientific grace.

In our September issue, shortly after the news of the dropping of the "atomic" bomb on Japan, we said that the industrial use of atomic energy as a prime mover would be with us within 20 years. This belief was not due to any supernatural powers in our make-up, but merely what we thought to be the result of the course taken by the study of nuclear physics.

Certainly many of the great scientists and other thinkers are in no doubt as to the possibility.

1. Professor Einstein (see the "Daily Telegraph," October 29, p. 4) is extremely cautious, but his actual words are: ". . . though the release of atomic energy can be, and no doubt will be, a great boon to mankind, that may not be for some time."

2. Dr. H. D. Smyth, chairman of the Department of Physics of Princeton University, member of the technical committee appointed in the U.S.A. to examine the possibilities of nuclear energy for technical development, is in no doubt. In his remarkably brilliant treatise, entitled "Atomic Energy," which was written under the auspices of the United States Government, and reprinted in this country by His Majesty's Stationery Office, he states:—

"While there was general agreement that a great industry might eventually arise, comparable, perhaps, with the electronics industry, there was disagreement as to how rapidly such an industry would grow; the consensus was that the growth would be slow over a period of many years. At least there is no immediate prospect of running cars with nuclear power, or lighting houses with radioactive lamps, although there is a good probability that nuclear power for special purposes could be developed within 10 years, and that plentiful supplies of radioactive materials can have a profound effect on scientific research, and perhaps on the treatment of certain diseases in a similar period."

3. Professor M. L. E. Oliphant, who led the British team of scientists co-operating in the production of the bomb, and is the inventor of the cavity magnetron, recently predicted the end of coal-mining as a large-scale industry, fuel and electric power being provided by uranium. He also stated that, while it is unlikely that uranium would be used for driving cars, "it is much more likely that ships and locomotives will be driven by atomic energy. They have bigger units and harnessing atomic energy would be more practical and economic."

To quote no other authorities, we conclude that the world is no longer flat.

Adhesives Based on Shellac and its Derivatives

By N. N. MURTY

INCREASING interest has been shown within recent years on the subject of adhesives, and in a series of articles[1] appearing in "Plastics" on the subject, adhesives based on synthetic resins have received adequate treatment. It is hoped the present article, which deals with adhesives based on shellac and its derivatives, which have been developed to meet the requirements mainly of the electrical industry, will form a useful adjunct to the foregoing series. There is an ever-growing need in modern industries for adhesives possessing high bond strength for materials like metals, wood, glass, bakelite and other plastics. Modern conditions of service also demand a high degree of resistance to heat, moisture, oil and vibrational stresses and in the electrical industry, good electrical insulating quality is yet another requirement. Among suitable adhesives preference will be given to those which are easy to apply and well adapted to the tempo of modern production. Rarely a single composition can be found which satisfies all the above requirements, therefore a number of adhesives based on shellac have been developed for special purposes which can be classified into three broad types based on the consistency or form in which they are handled: (1) "cements" in solid form for melt or hot spray application; (2) "adhesive pastes" in the form of putty or paste for application with the help of finger or palette-knife or for extruding out of collapsible tubes or special pressure applicator; and (3) "glues" having the consistency of syrup down to that of thin varnishes which can be sprayed or applied by means of a spray gun or brush. The above nomenclatures will be adhered to in this article to connote the types above mentioned.

Shellac, as is well known, possesses the useful property of adhering strongly to smooth surfaces like those of glass, glazed porcelain, metals, mica, etc. It finds extensive use in the electrical industry as the bond par excellence for the manufacture of mica-containing products. Owing to its comparative brittleness, however, its general use as an adhesive has been, up to now, limited. Also its adhesive strength to various surfaces, though high, is not adequate to enable the bond to withstand severe mechanical stresses and strains. These deficiencies in the natural product can be made good by suitable formulation of the adhesive. The theoretical considerations on which the formulation is based and which have found substantiation during the course of the investigation, may be described here with a brief reference to the constitution of shellac.

Shellac is composed of two resinous constituents, one of which, the "ether-soluble resin," is the low polymeric constituent which acts as a natural plasticizer to the other component, namely, "pure resin." The latter component can be polymerized under the influence of heat and/or accelerator giving a rigid but very brittle product. The ether-soluble fraction, on the other hand, cannot be polymerized. Shellac therefore exhibits a combination of properties intermediate between those of thermoplastic and those of thermohardening resins.

Both the components of shellac are composed of higher hydroxy acids, and the ability of shellac to adhere strongly to smooth surfaces is attributable to the orientation of the polar groups of these acids present at the interface, each oriented group serving as a point of anchorage to the surface. These hydroxy

acids are generally present in shellac in various chemical combinations with one another, the ester type of combination predominating, with the result that the concentration of free polar groups available in shellac which can participate in the bonding operation is limited.

The insufficiency in the plasticizing component can be made good by adding further quantities of the ether-soluble fraction, alternatively any plasticizer compatible with shellac can be used. Commercial cements based on shellac (e.g. Dekhotinsky's cement) make use of such plasticizers. The best type of plasticizer is, however, the resinous variety based on a derivative of shellac, [2, 3] which can combine with the parent substance in all proportions. In the formulation of shellac derivatives to be described, hydrolysed lac is used as the preferred plasticizing component as it is easy to manufacture (by alkali- or autoclave hydrolysis) and as it also contributes to the desired enrichment in polar groups.

Regarding the mechanism of adhesion of shellac to metals, it can be stated that only the free carboxyl groups present at the interface participate in the bonding, these being present as adsorption compounds on the surface of the metal through dipole attraction, the hydroxyl groups binding the oriented molecules through lateral cohesion to the mass of the adhesive bond. Among the various low molecular weight acids tried as promoters of adhesion to metals, hydroxy

Table 1.—Composition of Shellac-based Adhesives and Method of Mixing.

No.	Adhesive composition (parts by weight)					Type of adhesive	Method of mixing
	1 Orange shellac	2 Hydro-lized lac	3 Adhesion promoter, %	4 Filler	5 Solvent or dispersion medium		
1*	100	—	—	—	—	Cement	Melt mixed in agitated pot, roller or Banbury mixer, the filler being added after homogeneous mixing of the resinous components. (Temp. of mixing 110°–120°C., period 30–40 mins.)
2	75	25	—	—	—		
3	50	25	—	Mica† 25	—		
4	50	20	—	Mica† 20 Slate dust 8 Carbon black 2	—		
5	50	25	Malic acid 0.6 Tartaric acid 0.4	Mica† 24	—		
6*	—	100	—	—	Water 10	Adhesive paste	Mixed cold or just warm (40°–45°C.) in putty mill, item (3) being added in solution form using item (5)
7	—	98	Malic acid 2.0	—	Water 15		
8	—	98	Tartaric acid 2.0	—	Water 15		
9	25	100	Malic acid 1.2 Tartaric acid 0.6	—	Water 15		
10	20	100	—	Slate dust 60	Water 25		
11	20	90	Malic acid 4.0	Slate dust 60 or mica‡	Water 25		
12	—	100	Malic acid 3.0 Tartaric acid 1.0	Asbestos powder 40	Water 25		
13*	100	—	—	—	I.M.S.§ 233	Glue	Solution of item (1) in item (5), item (4) being stirred into the above solution
14	100	—	Tartaric acid 2.0	—	I.M.S.§ 233		
15	100	—	Tartaric acid 3.0	Mica‡ 122	I.M.S.§ 182		
16	100	—	Malic acid 2.0 Tartaric acid 0.9	Mica† 100	I.M.S.§ 204		
17*	100	—	—	Mica‡ 122	I.M.S.§ 182		
18‖	100	—	Borax 15.0 + sodium carbonate 5.0	—	Water 350		

* These compositions have been included as controls. † Wet ground mica (capable of leafing). Mica‡ can also be used in place of mica†. ‡ Micronized mica (capable of more uniform spread). § Industrial methylated spirits. ‖ Included for the sake of completeness (joints between Bristol boards are stronger than the material bonded).

Table 2.—Effect of Adhesion-promoters on Adhesion Strength of Metal Joints.

Ident. No.	Type	Adhesion promoter	Process of bonding	Adhesion strength (flexure)		
				Copper/copper	Brass/brass	Steel/steel
				lb./sq. in.	lb./sq. in.	lb./sq. in.
6	Adhesive paste	(Control)	Light pressure at 150°C. for 3 hrs.	120	54	38
7	Adhesive paste	Malic acid	Light pressure at 150°C. for 3 hrs.	132	62	118
8	Adhesive paste	Tartaric acid	Light pressure at 150°C. for 5 hrs.	199	170	177
8	Adhesive paste	Tartaric acid	Light pressure at 200°C. for 1 hr.	299	152	183
1	Cement	(Control)	Melt application to hot surface (contact pressure)	33	—	24
2	Cement	(Control)	Melt application to hot surface (contact pressure)	41	—	27
3	Cement	(Control)	Melt application to hot surface (contact pressure)	183	—	102
5	Cement	Malic acid	Melt application to hot surface (contact pressure)	—	—	108
13	Glue	(Control)	Pressure of 1,000 lb./sq. in. at 130°C. for 2 mins.	14	—	10
13	Glue	(Control)	Pressure of 1,000 lb./sq. in. at 130°C. for 2 mins. (film glue)	24	—	19
13	Glue	(Control)	Clamp pressure at 180°C. for 1 hour (film glue)	—	50	35
14	Glue	Tartaric acid	Clamp pressure at 180°C. for 1 hour (film glue)	61	—	52
16	Glue	Malic acid and tartaric acid	Clamp pressure at 230°C. for 1 hour (filler)	110	—	102

acids, particularly tartaric and malic were found suitable.

There is yet another factor which comes into consideration in the formulation of adhesives, namely, the effect of shrinkage on cooling the molten adhesive bond or on evaporation of the solvent from the adhesive solution which puts the resinous bond in a state of stress leading to easy fracture. Addition of fillers toughens the bond and contributes to added strength, and is particularly necessary in the case of gap-filling adhesives or in those cases where the glue-line is thick. The fillers chosen must be of an inert nature, and must at the same time be capable of being wetted by the adhesive vehicle. Among the various inert fillers investigated, slate dust and powdered mica were found to be particularly useful. The latter also contributes to the increase in the electrical insulation characteristics of the adhesive bond.

In Table 1 are given the compositions of various types of adhesives based on shellac and its derivatives, and their performance characteristics from the point of view of adhesion strength to metals are given in Table 2, the bond-strength being expressed as the load in pounds per square inch of bond required to cause failure of the joint when loaded in flexure. Suitable dimensions for the test metal bars are 4 ins. by $\frac{1}{2}$ in. by $\frac{3}{16}$ in., and two of these bars are bonded with the adhesive under examination so as to give an end on lap joint of area 1 in. by $\frac{1}{2}$ in. The test specimen is supported over two wedges as shown in Fig. 2 and loaded in flexure at the centre of the joint through a wedge which is rubber lined to minimize shock loading. The load is applied at the uniform rate of 80 lb. per minute by a machine developed for the purpose and illustrated in Fig. 7. (Butt-joint may be used in place of the lap-joint where convenient and where such test is desired.) The flexural test is easy to perform and gives values which have far greater practical significance than those obtained by testing the joint in pure tension or shear.

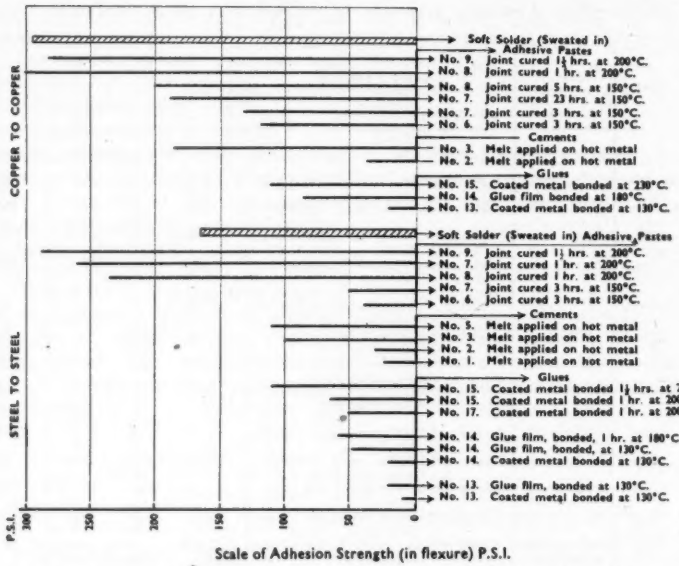

COPPER TO COPPER
Soft Solder (Sweated in)
Adhesive Pastes
No. 9. Joint cured 1½ hrs. at 200°C.
No. 8. Joint cured 1 hr. at 200°C.
No. 8. Joint cured 5 hrs. at 150°C.
No. 7. Joint cured 23 hrs. at 150°C.
No. 7. Joint cured 3 hrs. at 150°C.
No. 6. Joint cured 3 hrs. at 150°C.
Cements
No. 3. Melt applied on hot metal
No. 2. Melt applied on hot metal
Glues
No. 15. Coated metal bonded at 230°C.
No. 14. Glue film bonded at 180°C.
No. 13. Coated metal bonded at 130°C.
STEEL TO STEEL
Soft Solder (Sweated in) Adhesive Pastes
No. 9. Joint cured 1½ hrs. at 200°C.
No. 7. Joint cured 1 hr. at 200°C.
No. 8. Joint cured 1 hr. at 200°C.
No. 7. Joint cured 3 hrs. at 150°C.
No. 6. Joint cured 3 hrs. at 150°C.
Cements
No. 5. Melt applied on hot metal
No. 3. Melt applied on hot metal
No. 2. Melt applied on hot metal
No. 1. Melt applied on hot metal
Glues
No. 15. Coated metal bonded 1½ hrs. at 230°C.
No. 15. Coated metal bonded 1 hr. at 200°C.
No. 17. Coated metal bonded 1 hr. at 200°C.
No. 14. Glue film, bonded, 1 hr. at 180°C.
No. 14. Glue film, bonded, at 130°C.
No. 14. Coated metal bonded at 130°C.
No. 13. Glue film, bonded at 130°C.
No. 13. Coated metal bonded at 130°C.
P.S.I.
300
250
200
150
100
50
0
Scale of Adhesion Strength (in flexure) P.S.I.

Fig. 1.—Showing the magnitude of adhesion strength obtained with various types of adhesives used for bonding metal to metal.

Effect of Adhesion Promoters on Adhesion Strength

It will be seen from Table 2 that, regardless of the type of adhesive, the addition of malic and/or tartaric acid contributes to increased bond strength. The effect is particularly noticeable in the case of bonding steel with adhesive pastes based on hydrolysed lac where a threefold increase in bond strength results on addition of malic acid. The two hydroxy acids above referred to are also helpful in mitigating or even preventing the corrosive action of shellac acids on the metals being joined or on metallic containers. It is at the same time necessary to observe that the minimum quantity of these promoters should be used in the formulation of the adhesives in order to minimize their adverse effect, particularly that of tartaric acids, on water-resistance.

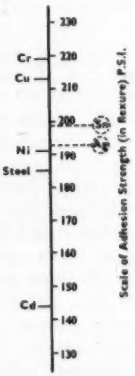


Fig. 3.—Showing the magnitude of adhesion strength obtained between two similar metals using adhesive pastes.

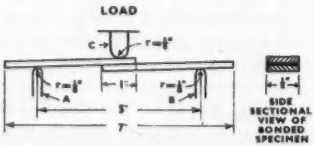


Fig. 2.—Bonded metal specimen under flexural load. A and B are supporting wedges, and C is the loading wedge.

Effect of Adhesive Formulation and Bonding Procedure on Adhesion Strength

The maximum improvement in the bond strength of various classes of adhesives under different conditions of bonding is graphically illustrated in Fig. 1. It will be seen in this figure how the use of unmodified shellac and poor bonding technique results in very low adhesion strength (10-20 P.S.I.), and how, under suitable formulation and correct bonding procedure, the adhesion strength can be increased to an entirely different order of magnitude. Adhesive pastes based on hydrolysed shellac show the highest strength (200-300 P.S.I.), sometimes even exceeding that shown by metal joints using soft solder. Next in order of strength come the cements, and here the effect of filler in contributing to overall bond strength is clearly noticeable. This is also illustrated in the case of glues which require a filler either incorporated into the varnish or as support for the glue-film in order to impart toughness and strength to the adhesive bond. Paper is generally used as the supporting material for the glue-film and after evaporation of solvent a dry film results, which can be used as sandwich between metal surfaces, heat and pressure completing the bonding operation. The technique corresponds to the film-glue method of bonding wood veneers, but differs in object when bonding metals. The paper-ply prevents metal-to-metal contact and ensures adequate electrical insulation.

Conditions of Bonding

It will be seen from Fig. 1 that for adequate bond strength high temperatures have to be employed for bonding at which a material like paper undergoes charring. Also a reference to Fig. 4 will reveal that the glue-film must be in as "green" a state as possible to obtain high bond strength. Condensation-polymerization which proceeds during the prebaking of the film-glue reduces the number of free polar groups and their ability to orient themselves towards the metal surface. A higher temperature for bonding becomes therefore necessary. In such cases glues incorporating mineral fillers are to be preferred as the temperature of bonding can be taken to the decomposition limit of shellac.

Adhesion Strength in Relation to Type of Metal Bonded

In Fig. 3 is shown in graphic form the magnitude of adhesion strength obtained when the nature of the metal bonded differs. The test specimens for these experiments were prepared by electroplating mild steel bars of the dimensions already specified with the metals under investigation. The adhesive compositions used for bonding belonged to the type "adhesive pastes," modified with malic and/or tartaric acid, but containing no fillers. Against the mean value of bond strength on the adhesion strength scale are noted the respective metals. As only four individual values were available in the case of silver and tin, their position on the scale is doubtful and is therefore indicated by dotted lines. It will be seen from this graphic representation that a metal like cadmium with high atomic volume occupies the lowest position on the adhesion scale. Apparently the degree of packing in the lattice structure of the metal and the cohesive forces within have an influence, among other surface properties, on the adhesion characteristic of the metal surface. But, by and large, the actual adhesion strength obtained with composite adhesives is governed by specific influence of the ingredients in the composition on the various metal surfaces. This is probably the reason why the order of strengths obtained with various metals here do not strictly correspond with those reported by McBain[4] et al. It should, however, be noted that, irrespective of the composition, shellac-based adhesives possess greater adhesiveness to copper than to steel surfaces (c.f. Table II). The intermediate position occupied by brass when employing unmodified shellac or hydrolysed shellac as the adhesive is upset on inclusion of adhesion promoters in the composition and the strength of the steel joints approaches that of copper joints.

F

wedges, and C is the loading wedge.

on water-resistance.

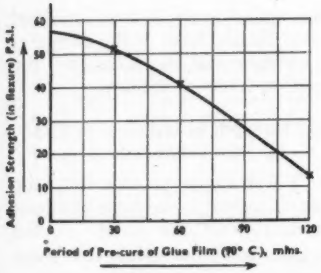


Fig. 4 (above).—Illustrating effect of pre-cure of film glue on adhesion strength.

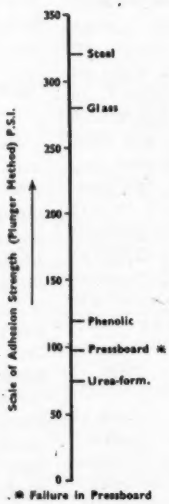


Fig. 5 (centre). — Showing the magnitude of adhesion strength of various materials bonded to phenolics with No. 3 cement.

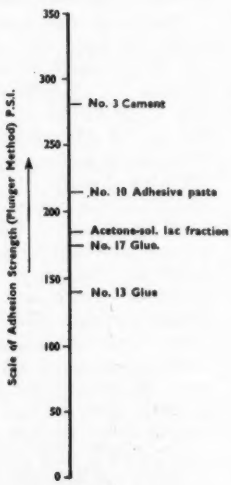


Fig. 6 (right).—Showing the magnitude of adhesion strength of various adhesives used for bonding glass to phenolics.

* Failure in Pressboard

In the case of aluminium alloys the method of test consisted in using duralumin sheets of dimensions 1 in. by $\frac{1}{2}$ in. by $\frac{1}{16}$ in. as sandwich between steel or copper joints, adhesive No. 12 being used to coat the mating surfaces. Adhesion strength was also tested in shear using duralumin strip specimens (1 in. by $\frac{1}{2}$ in. lap joint) and adhesive No. 11 for bonding. Below are given the mean value of adhesion strength for each type of joint.

Type of joint	Joint strength p.s.i.
Cu/Al/Cu	272
St/Al/St	50
Cu/Al/Al/Cu	290
Al/Al (shear)	1,167
St/St (shear)	799

It will be seen from the above figures that stronger joints are obtained when bonding duralumin to duralumin or duralumin to copper than when bonding duralumin to steel or steel to steel.

Adhesion Strength in Relation to Various Types of Bonded Materials

The experiments heretofore described have been confined to the subject of metal to metal bonding with shellac-based adhesives. It is now proposed to deal with the applicability of these adhesives for bonding other types of materials. For elucidating the bond strength of the adhesive in the case of these materials (which are not suitable for bending test in the form of bar specimens), the test specimen consists of a board of one of the materials with holes $\frac{3}{4}$ in. diameter drilled in it, and the other material in the form of 1-in. square pieces is bonded to the board so that the square pieces are centrally aligned in respect of the holes. The test for adhesion strength consists in determining the load necessary to force a plunger through the hole so as to separate the bond. The plunger and the board specimen used for this purpose are clearly visible in the photograph (Fig. 7). In Fig. 5 are shown the adhesion strength of various materials to smooth bakelite surface using No. 3 cement. It will be seen from this figure that steel and glass can be more firmly bonded to a smooth phenolic surface than either urea-formaldehyde or even the resin itself. Examination of the broken joints reveals that the adhesive is more firmly bonded to the glass or steel surface than to the smooth bakelite surface. It is possible by roughening the surface of

bakelite to get even stronger joints where mechanical keying supplements specific adhesion.

Of particular importance to the electrical industry is a cement for fixing glass windows to the bakelite case of meter, relays and other instruments which must satisfy, among other requirements, the demand for high bond strength. Various adhesives tested for joint strength between glass and smooth bakelite surfaces are shown on the adhesion scale in Fig. 6 against their respective joint strength. It will be seen that among the adhesives tested, No. 3 cement possesses the highest bond strength for this class of materials.

Conclusion

High bond strength shellac-adhesives can be prepared by incorporating a plasticizer like hydrolysed lac, an inert filler like mica or slate dust and an adhesion promoter like tartaric- or malic-acid into the composition. The possible application of these adhesives is listed in Table 3. Some of these adhesives have already proved their merit in actual industrial use. The practical attainment of the full bond strength the listed adhesives are capable of depends not only on their composition but also on the bonding technique employed and the care exercised in preparing the surface. In this latter respect, shellac-based adhesives are less exacting, for it is not necessary to roughen the surface to obtain high bond-strength. It is, however, essential to remove any grease present on the surface and, when bonding metals, it is essential to remove the oxide scale by acid pickling or by other means, as otherwise the bond will be no stronger than that existing between the oxide scale and the metal. This precaution is particularly important when bonding electrical sheet steel laminations.

In summing up it is necessary to stress the fact that shellac-based adhesives, apart from possessing high bond strength to smooth surfaces, show high resistance to attack by transformer oil and petroleum type of hydrocarbons. Also their strength is not adversely affected by ageing as in the case of certain synthetic resin adhesives.

High bond strength at room temperature is not, however, the only consideration in the selection of an adhesive. Where operating temperatures are high

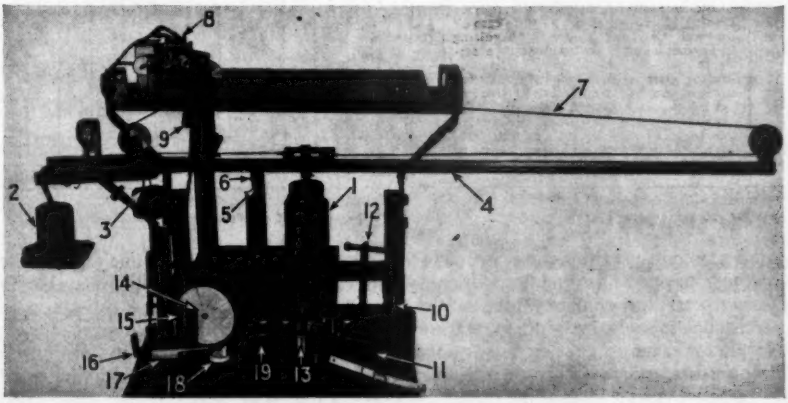


Fig. 7.—Experimental Adhesion-testing Machine.

1. Riding weight. 2. Counterweight. 3. Adjustable counterweight. 4. Beam on which (1) rides. 5. Test specimen (flexural). 6. Loading wedge for (5). 7. Rope actuating (1). 8. Geared motor, winding rope (7). 9. Hand crank for resetting (1). 10. Plunger for loading. 11. Meter case with bonded glass window. 12. Loading pad. 13. Bonded tensile test specimen and grip. 14. Bonded aluminium rotor. 15. Bonded block of steel laminations. 16. Bonded core laminations. 17. Bonded carbon strain gauge on deralumin. 18. Bonded porcelain specimen. 19. Test specimen for plunger-type loading.

Table 3.—Possible Application of Shellac-based Adhesives.

(Tentative picture; letters A, B and C signify suitability in decreasing order of merit.)

No.	Type of bonding job	Type of adhesive*												
		2	3	4	5	7	8	9	10	11	12	14	15	16	18
1	Small rotor laminations, high operating temperature, grinding finish	—	C	—	B	—	—	—	—	—	—	—	A	B	—
2	Small rotors, high insulation, high space factor	—	—	—	—	—	—	—	—	—	—	A	—	—	—
3	Aluminium rotor disc laminations of meters, high insulation	—	—	—	—	—	—	—	—	—	—	A	—	—	—
4	Core laminations of electrical instruments (e.g., coil short-circuit tester)	—	A	—	A	—	—	—	—	—	—	B	B	B	—
5	Laminations bonded to wedge shape and radial segment form (e.g., induction accelerators)	—	A	—	A	—	—	—	—	—	—	B	B	B	—
6	Wood, fibreboard, cork composition, pressboard or similar absorbent material to sheet metal	B	A	—	A	—	—	—	—	—	—	B	—	—	—
7	Paper or cardboard scale to metal backs	—	A	—	A	—	—	—	—	—	—	A	—	—	—
8	Paper, cardboard and cellulose materials (not too absorbent a surface) to each other	—	—	—	—	—	—	—	—	—	—	B†	—	—	A†
9	Paper labels to glass bottles, tins, metal boxes, etc.	—	—	—	—	—	—	—	—	—	—	A†	—	—	—
10	Absorbent surfaces to each other, to overcome glue starved joints (e.g. unglazed porcelain, asbestos board, cement concrete, etc., and the materials mentioned in row 6)	—	A	—	B	—	—	—	—	—	—	B	—	—	—
11	Sealing cements for cracks and leaky joints in metals and castings	B	C	—	C	A	A	A	—	—	—	—	—	—	—
12	Sealing and filling cracks in wood (e.g., furniture)	—	A	—	B	—	—	—	—	—	—	—	—	—	—
13	Metal to metal (general) for high joint strength and resistance to impact	—	B	—	B	—	A	A	—	A	A	—	—	—	—
14	Glazed porcelain, mending broken china, glassware, etc.	B	A	—	B	—	B	—	A	—	—	—	—	—	—
15	Fixing handles to cutlery, mending toys, etc.	A	A	—	B	—	—	—	—	—	—	—	—	—	—
16	Temporary joints capable of easy and clean separation (e.g., carbon strain gauges to machine parts under vibration study), high insulation	A	B	—	B	—	—	—	—	—	—	—	—	—	—
17	Bonding glass, metals, etc. to smooth bakelite surface (general)	B	A	—	A	—	B	—	B	—	—	—	—	—	—
18	Bonding glass window to bakelite case of meters, relays and instruments requiring easy technique; low temperature service	—	A	B	B	—	—	—	B	—	—	—	—	—	—
19	Bonding glass window to bakelite case for tropical service (for extreme tropical climates, recommend covering with moisture resistant coat in addition to curing)	—	B	A	C	—	—	—	—	—	—	—	—	—	—
20	Capping cement (e.g., fixing bases to radio tubes)	—	B	A	C	—	—	—	—	—	—	—	—	—	—

* For composition c.f. Table 1.

† Where colour is objectionable, bleached or decolorised shellac should be employed in formulating the adhesive.

or the ambient conditions are associated with high temperature and humidity (as in extreme tropical climates), factors such as resistance to moisture and temperature-deformation assume greater importance. The moisture and temperature resistance of shellac adhesives can be raised by employing a high temperature baking schedule. The addition of polymerization accelerators to promote cold or low temperature hardening is not admissible as they adversely affect bond strength.

It must be noted that while an increase in the proportion of hydrolysed lac in the composition promotes resistance to mechanical vibration and impact stresses mainly by conferring ductility, prolonged period of cure is necessary for the bond to harden and develop the full bond strength. Even so, continued application of load can produce failure of the joint due to creep. These facts should be borne in mind when selecting an adhesive

(Continued on page 624)

THE LADY DOESN'T CARE—

if it pours

THE two waterproofs shown above have reached this country by divers means from Germany and Italy respectively. They are both made of polyvinyl chloride sheet.

That on the left, the German one, is of a transparent iron grey and is 5/1,000 in. thick. It is of the cloak type buttoned in front without arms, but is fitted with a hood.

The other is of the conventional coat type with sleeves, transparent egg-shell blue in colour, and stronger than the dark coloured one, being 10/1,000 in. thick. A separate headpiece and a belt are provided. As will be seen from the photographs, both drape exceedingly well.

A surprising fact is that both waterproofs are sewn with thread and have not been welded by any of the well-known methods. There is no doubt that Germany knows as much about these processes as any other country, so that we presume that H.F. machinery was not readily available, or that existing labour in the tailoring trade had to be employed. Judging from the slight flaws already present in the coats, sewing with thread is not the process to employ with polyvinyl sheet.

The Microscopic Examination of Plastic Materials

V.—Insulating Sleevings (contd.)

By J. H. WREDDEN, F.R.M.S.
(Chief Chemist, Igranic Electric Co., Ltd.)

AS a result of examining the structures of the cotton fabric-based sleevings, we see that they possess several characteristics liable to lead to premature failure in service. Chief of these are the unimpregnated condition of the cotton yarn and voids in the varnish mass. The first of these features leads to high moisture absorption, which will take place through the unprotected cotton, and as a very low moisture absorption is probably the most important characteristic desired from the electrical point of view, a much more homogeneous structure is desirable.

The question of the presence of voids is important, inasmuch as their contents are generally of a gaseous or vapour nature, and usually under reduced pressure. The effects of high voltages on these substances are too well known to need description; for example, the sleeving under discussion may be broadly looked upon as consisting of a "sandwich" of air, cellulose, starch and the gaseous reaction products due to drying, present between two outer layers of varnish. The varnish itself is a very good electrical insulator, and the effect of applying a voltage between the outer surfaces of this "sandwich" will be, in the main, to cause high local concentrations of ozone, which will attack the varnish layers from the inside, apart from establishing a conducting layer. Thus it will be seen that the formation of voids will tend to reduce the electrical strength of the material, and, in cases where large volumes of air are present, the possibility of the occurrence of sufficient ozone to disintegrate entirely the films of varnish, should be taken into consideration.

Voids of a dangerous size exist in the specimen numbered 1A (see Table 1, November issue), so we may examine some of these in relation to the general structure of that particular sleeving. Fig. 42 shows another portion of the same section given in Fig. 34 (see November issue), and at the same magnification of 50 diameters. In this case we see the presence of large voids at the places marked A and smaller ones at B clearly demonstrated; in fact, the whole may rightly be assumed to be virtually "honeycombed" with these voids; it is estimated that approximately 20 per cent. of the total volume of the sleeving is occupied by air and other gaseous substances, taking into account the air in the interstices of the yarn.

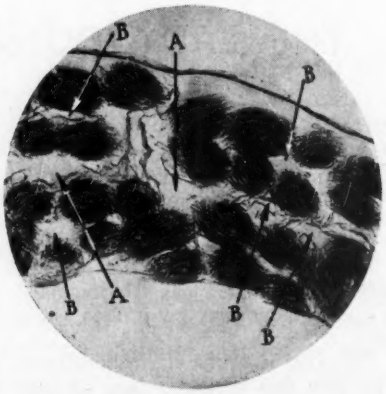


Fig. 42.—Transverse section of varnished cotton sleeving 1A, showing large voids. (Magnification : 50 diameters.)

If we now refer to Fig. 43, again the same section as in Fig. 42, the presence of an exceptionally large void is demonstrated at A, but it must be borne in mind that this space is really somewhat smaller than it seems, as the section is broken at B; nevertheless, after making due allowance for this, the void may be considered as being dangerously large; smaller voids are shown at the points marked C, and it is interesting to note how they occur at the junction of three or more bundles of yarn. At the point D we have an interesting phenomenon, inasmuch as there occurs a cluster of small bubbles, similar to those encountered in our examination of laminated materials. These clusters occur here and there throughout the structure of these sleevings and would appear to be due, largely, to similar causes, i.e., the trapping of solvent vapours inherent in the varnish, but the possibility of smaller voids (C), being due to large numbers of the bubbles breaking down into one larger one, must not be overlooked, although in this case the addition of air from the interstices of the yarn is highly probable, as this would presumably be under some pressure, due to the stoving temperature. This photomicrograph also clearly shows the manner in which the varnish shrinks away from the surface of the yarn; some points where this has occurred are shown at E. As has been suggested, this is, in all probability, due to the previously mentioned controlling factors being unbalanced; in fact, we would be quite justified in assuming that this is so for all the varnished cotton braid sleevings examined.

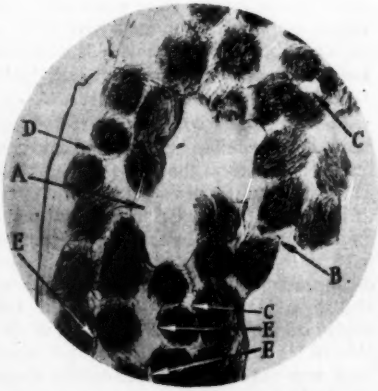


Fig. 43.—Transverse section of varnished cotton sleeving 1A, showing very large voids. (Magnification : 50 diameters.)

The question of the use of solid continuous fibres has been stressed previously, together with the necessity for complete impregnation of the textile. This has been more or less put into practice in the Group 2 materials, these being a varnished artificial silk braid. In the article on "Radio Wiring Insulation" (see June issue), only one sample of this group was dealt with, the reason for this being the scarcity at the time; however, the author has since been able to obtain a sample of a pre-war sleeving of this type, constituting a comparative example.

Previous discussions on the suitability of continuous fibres included the question of the choice of the best fibre to use for any particular processing method, so before proceeding with the analysis of the structure of the Group 2 materials, a brief discussion of this point will not be amiss.

As is well known, the artificially produced cellulosic fibres may be broadly classified under two main headings, i.e., those composed of regenerated cellulose, such as viscose and cuprammonium, and the cellulose esters, such as cellulose nitrate and acetate. The esters "silks" are seldom used, due to their comparative instability as compared with the regenerated cellulose materials, but a comparison of the behaviour of these materials in the presence of moisture is illuminating. Let us first consider the question of moisture content; these materials are known to be capable of taking up not inconsiderable quantities of moisture after desiccation. This propensity is important in so far as any moisture content must, of necessity, have an adverse effect on the electrical properties. Thus, cotton may be regarded as being capable of taking up as much as 7 per

cent. of moisture, calculated on the desiccated weight, and viscose and cuprammonium are said to be capable of an intake of anything up to 11 per cent., whereas cellulose acetate will accept up to 9 per cent.

It is not proposed to discuss the mechanism of this moisture intake, be it by absorption or adsorption, but rather to show that the question of the condition of the fabric prior to processing is of prime importance. It will, therefore, be appreciated that the yarn must be quite dry when processed, otherwise the best electrical properties of the base material will not be fully developed, apart from which an undried condition would suggest a possible cause of bubble formation, due to the evolution of water vapour during the stoving process; indeed, as it is not usual to take any special care to ensure that the fabric is thoroughly dry before varnishing, the explanation of the presence of the larger voids or bubbles would seem to lie in this direction. Apparently, therefore, the tenth point raised (see November issue) regarding the condition of the yarn and under which heading this question of moisture intent lies, assumes a greater significance when viewed in conjunction with the other operative functions suggested.

Suppose we now examine the structure of the first-mentioned Group 2 material in the light of the assumption that a perfectly dry material is a paramount necessity. A photomicrograph of a transverse section of this varnished silk sleeving at 50 diameters is shown at Fig. 44, on examination of which we are immediately confronted with an apparent anomally, for, having reiterated that a solid continuous fibre-based material would show superior results to one based on staple cotton fibre, we find that the moisture absorption of this particular material is 18.5 per cent. (Table 4, November issue), which is almost exactly double that of the worst of the varnished cotton sleevings, viz., with a moisture absorption of 9.76 per cent.

This would at first sight tend to throw grave doubts on the validity of the previous hypotheses regarding types of base material, but when we examine the section (Fig. 44) we see that the base material is almost entirely unimpregnated. The varnish film, which consists again of three coats whose interfaces are marked A, B, and C, appears to be just on the surface of the yarn; it has, in fact, penetrated slightly to the depth shown at point D, where the section has been bent back on itself (unintentionally), thus allowing two overlapping portions of the yarn to separate at points where there is no varnish, which latter holds them in position where penetration has taken place.

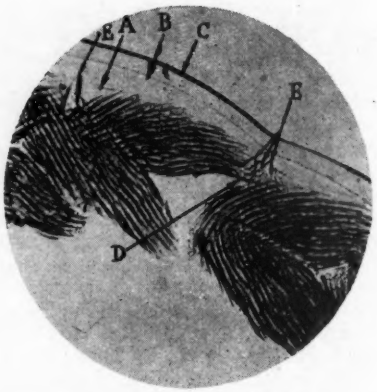


Fig. 44.—Transverse section of varnished art-silk sleeving 2. (Magnification: 50 diameters.)

The yarn itself will be seen to be very heavy, the peculiar herringbone arrangement being due to the fact that the braid is bias woven, which would give this effect in a section taken at right angles to the axis. Thus, it will be seen that the entire base material, in this case a viscose yarn, is unprotected in any way and free to absorb and adsorb moisture to the full extent of its capabilities, which for this material is anything up to 11 per cent. This does not take into account the water absorbed by capilliary attraction when the sleeving is immersed; obviously, with these smooth continuous fibres, this will

be high, furthermore, moisture absorbed by this method is dependent on the number and length of the capilliary paths between the filaments of the yarn. Therefore, in this case, the conditions for the successful absorption of large quantities of water are good, for, in the first instance, we have large numbers of capilliary spaces due to the weight of the yarn, this signifying the presence of a great many filaments; secondly, the method of weaving lends itself admirably to high capilliary absorption, as the paths would take a " zigzag " course through the fabric and hence would be considerably longer than would be the case in a square-woven fabric, where the capilliary spaces may be regarded as lying parallel to the long axis of the braid. In this manner we could account for the high moisture absorption figure; obviously, if the entire fabric were embedded in the varnish, the capilliary spaces would not exist and the yarn would be protected from its natural tendency to take in moisture, assuming that it was quite dry when varnished. The total moisture absorption would then be negligible.

Thus we see that the situation is not as contradictory as was first thought to be the case. On the contrary, it serves as a graphic illustration of the effects of not impregnating the base material, as we shall see that complete impregnation brings about a startling reduction in the moisture content of these materials. There are no voids in this section because there are no places where voids could be developed, due to the absence of varnish; instead, the fabric would be full of air and moisture when the initial coat of varnish was applied, on stoving the air would expand and the moisture be converted to vapour, both of which would exert a pressure on the internal surface of the varnish film. This in itself would be a considerable deterrent to the penetration of the varnish, although much would escape through the film. It would appear that, in this particular case, the first coat was too rapidly stoved, thus allowing these gases to be trapped in their passage through the film; some of the points at which this has occurred are shown at E (Fig. 44). It can well be imagined how the air and water vapour at some elevated pressure would find a weak spot in the solidifying film, which would result in a miniature volcanic eruption, resulting in the formation of these tiny prominences on the surface of the first coating; this would mean that at the apices of the cones the effective thickness of the total varnish film is practically halved, with its attendant deleterious effects on the electrical properties of the varnish coating as a whole.

Now let us examine another specimen of varnished art-silk sleeving. In this case the material was made before the war and is a high-grade product; it is based on a cuprammonium braid. A photomicrograph of this material in transverse section is shown at Fig. 45, the magnification being again 50 diameters; examination of this illustration immediately shows this material to be very much thinner, overall, than the previous material, as a result of which it was very difficult to prepare a really thin section without causing any damage; as it is, the portion shown has suffered somewhat in the processing. However, enough of the section is undamaged for the purpose of illustrating that the fabric in this case is

Fig. 45.—Transverse section of varnished art-silk sleeving. (Pre-war.) (Magnification : 50 diameters.)

completely embedded in the varnish matrix.

This is clearly shown in that portion of the section marked A, from which it will also be seen that the filaments are very much the same size as in the subject of Fig. 44, but that the yarn itself is very much lighter, i.e., it does not contain as many filaments as in the other specimen. This will, of course, help the impregnation considerably, although this latter might have been made easier still by having a looser yarn. In this case the yarn is fairly tight, and it is suggested that a yarn with fewer twists per inch would have greatly assisted the penetration; however, in this sample we have a material whose structure is close to the ideal of complete homogeneity, with the result that the moisture absorption is as low as 0.86 per cent. This is a considerable improvement on the previous specimen, and when it is remembered that the same materials were used to fabricate both samples, the supreme importance of using the best processing methods in conjunction with careful control of all the operative methods influencing the structure of the final product, becomes apparent; also, it would seem that the moisture absorption of these materials is so closely related to their micro structure that the more or less "rule of thumb" methods at present adopted in their manufacture should be replaced by more precise ones. It will be obvious that close co-operation is required of the three industries involved, viz., the textile industry, the varnish manufacturer and the processor.

Before proceeding with a discussion of the next group of sleevings, it would perhaps be as well to point out that the knowledge obtained from our examination of the structure of these materials so far may very well be applied to the processing of the laminated materials discussed in preceding articles. For example, the previously quoted factors, whose complexity of function makes the whole question of impregnation so involved, may very well be studied and put into controlled operation in the impregnation of base materials prior to fabrication.

Let us now examine the Group 3 materials. These consist of the sleevings made up of a rolled varnished silk tube on which is a braided cotton covering. In the original tests on these samples, products from four different manufacturers were involved, i.e., 3a, 3b, 3c and 3d (see July issue); of these four materials a, b and d were of the same type, c being somewhat different, therefore, for the purpose of discussing the structure, only two samples will be taken for examination, 3a to represent the majority, 3c being the one differing from the others.

Transverse and longitudinal sections of 3a at 48 diameters have already been illustrated in Figs. 35 and 37 respectively (November issue). The transverse section in Fig. 35 was described, the double layer of varnish was shown, together with the cotton, which, in this case, was further treated with a pigmented lacquer, the purpose of which was also made clear. The wide differences between the structure of the varnished silk and cotton braid were stressed as representing the good and the bad, existing simultaneously in the same material. Very large voids in the outer covering were shown, together with large masses of lacquer surrounding the cotton yarn, but not penetrating it. In comparison with this, the varnished silk was shown to consist of a continuous resin matrix, embedded in which were the natural silk fibres.

Having refreshed our memories with regard to the general structure of this sleeving, let us examine it at somewhat higher magnification, commencing with the varnished silk. This is shown in section in Fig. 46, which is a photomicrograph at 200 diameters. This photograph was very difficult to obtain owing to the extreme transparency of the subject, necessitating the use of a small cone of light to develop the little contrast available. However, it is sufficiently clear how closely this structure approaches the ideal condition, and we see that the varnish matrix consists of a single impregnating coat A, on top of which is applied

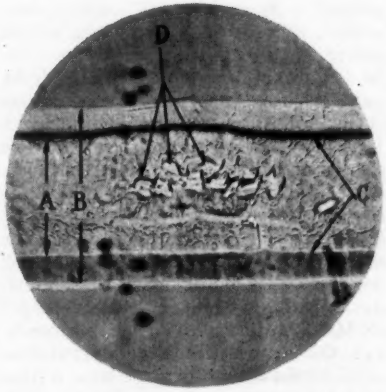


Fig. 46.—Transverse section of varnished natural silk from sample 3A. (Magnification: 200 diameters.)

the finished coat B, the varnish-to-varnish interfaces of the two coats occurring at C. The pecular markings covering the varnish surface are artificially produced in the cutting of the section and are collectively known as an "Artifact" and must not be interpreted as part of the section By way of a slight diversion, the author would like to point out that this photograph is a classic example of the misleading results produced by incorrect lighting, for the cone of light required to illuminate this section was so small that all semblance of a truly critical image ceased to exist. The result is that spurious structures are revealed, which would not have been seen if the section had been critically illuminated, but, then, in this particular case, neither would the true structure have been visible, so we are forced to put up with an inferior image in order to see anything of the structure at all.

This point is stressed more in the nature of a warning to those users of the microscope who do not use correct illumination or have not studied the subject as such, for it is all too easy to give credence to the presence of structures which in reality either do not exist at all, or are produced in the processing of the specimen. Also, the true appearance of the image is distorted and very often so altered as to be unrecognizable as such. This is well shown in the illustration under discussion at the points marked D, where we have the individual filaments of the natural silk yarn in cross section. One might say that these are quite obviously the filaments, and so they might be, but, if we had not previously seen a true image of typical silk fibres in cross section, as shown in Fig. 5 (see July issue), we would have no idea of the real shape of the filaments; a comparison of Figs. 46 and 5 will make this clear.

As it is, the filaments in Fig. 46 are distorted beyond recognition, so also would be the case with any other yarn under these conditions, which shows the impossibility of identifying a particular yarn. In this case the yarn might well be mistaken for any of the viscose filaments and so give an entirely misleading result. Thus it is as well to bear in mind that one should always endeavour to obtain a really critical image if desirous of producing results which can be relied on, for, like other precision instruments, the microscope is liable to be responsible for the most chaotic conclusions and hypotheses if full advantage of its capabilities is not taken.

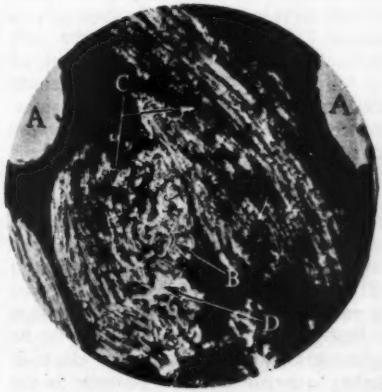


Fig. 47.—Transverse section of cotton braid covering of sample 3A. (Magnification: 200 diameters.)

However, in continuing our examination of this sleeving, we see that the silk fibres comprising the yarn are completely embedded in the varnish, that is to say, the varnish surrounds each individual fibre, thus constituting a homogeneous structure in which we have the previously mentioned condition of a continuous matrix carrying the base material.

This is the first instance in which we have met with this structure as a "fait accompli," for up to now it has existed purely as a hypothesis, which shows that the accomplishment of the theoretical concept is by no means impossible and, furthermore, the results shown by the practical application of this theory do full justice to its development, for the moisture absorption of this material is of the order of 0.5 per cent.; also, it will be noticed that this high resistance to moisture has been obtained with only two coats of varnish, whereas the varnished cotton material possesses at least three and sometimes four coats and cannot be compared to natural silk for moisture absorption.

In the same manner the electrical properties of this varnished silk are much superior to those of the cotton based material, as will be seen by a comparison of their dielectric strength. That for the cotton based material being of the order of 500 volts/mil (R.M.S.) taken on a sample 7 mils thick, whereas the silk material, with an average thickness of 3.5 mils, showed a dielectric strength 1,591 volts/mil (R.M.S.). The significance of these results is shown by the actual puncture voltage of the materials in question, thus the cotton based sample with a thickness of 7 mils broke down at 4,500 volts (R.M.S.), whereas the silk, with its thickness of only 3.5 mils, broke down at 5,600 volts (R.M.S.), so that it will be seen that for the cotton material to possess the same breakdown voltage as that of the silk, it would have to be approximately 11 mils thick, which is slightly over three times as thick as the silk.

Thus are the basic principles underlying our original hypothetical ideal proved by practical application.

The poor comparison shown by the cotton based material is, presumably, due to the incomplete impregnation of the yarn resulting in the presence of masses of air and other undesirable substances. It is, however, of some interest to note that even in the unvarnished condition, natural silk fabric is superior to cotton, thus natural silk fabric of an average thickness of 1.57 mils gives a dielectric strength of 215 volts/mil (R.M.S.), whereas cotton fabric 5 mils thick shows a dielectric strength of 125 volts/mil (R.M.S.), so that even in the raw condition the natural silk is nearly twice as good as the cotton; here we have further evidence supporting the use of the high-grade continuous fibre.

So much then for the inner lining, as it were, of this material. We may now turn our attention to the cotton braid covering, a portion of which is shown in Fig. 47, photographed at a magnification of 200 diameters.

This illustration clearly shows the absence of the coloured finishing lacquer from the interstices of the cotton yarn, although it should be borne in mind that the lacquer is, in all probability, only intended as a binding agent to hold the yarn together and not as the insulator, but the possibility of this structure causing a general depreciation of the electrical properties of the whole must not be overlooked.

However, the photomicrograph shows how the binding lacquer has flowed round the yarn without penetrating it, also the presence of voids in lacquer, shown at A, will be noticed. There are many of these voids throughout the texture of the braid and in the majority of cases are far too large for comfort.

The yarn itself is of the usual massive construction, a group of cotton fibres in transverse action being shown at B; in several cases the bore of the fibre will be seen to be quite open.

At places such as those shown at C, it will be noticed that the lacquer has penetrated the yarn structure to a certain extent. This, of course, demonstrates the

yarn to be of loose construction, because, so far as the author is aware, no special measures are adopted to ensure perfect impregnation of the yarn by the lacquer, and therefore this small degree of penetration would appear to indicate a loose yarn and also serve to emphasize the lack of penetration elsewhere on the yarn. A further indication of the looseness or lack of twist in this yarn is the presence of spaces in the actual structure of the yarn as shown at D; these, like the voids in the lacquer, are also fairly numerous. The significance of the voids and the raw cotton has already been stressed and it will be seen why the moisture absorption of this material is so high. Reference to Table 4 (November issue) shows this material (3a) to have a moisture absorption of 6.93 per cent., which, with the exception of 1c, is higher than any of the Group 1 materials.

Thus it would appear that this material is inferior as an electrical insulator to the varnished cotton fabrics. In addition, it seems that the use of the cotton braid covering on the varnished natural silk results only in a considerable negation of the excellent electrical properties of this latter, for the dielectric strength of the complete sleeving is no better than that for varnished cotton (see Table 1, "Radio Wiring Insulation," Tucker and Wredden, "Plastics," June, 1945), being of the order of 300-500 volts/mil (R.M.S.), whereas the dielectric strength of the varnished natural silk itself is, as we have seen, 1,591 volts/mil (R.M.S.). Therefore one would be quite justified in asking why a first-class material like the natural silk should be so prostituted in producing a material which, in the end, is actually inferior to varnished cotton (electrically) and yet costs something like three or four times as much as this latter. Admittedly it may be superior mechanically, but the author would venture to suggest that the means adopted to achieve this end are inclined to be expensive. Indeed, it is difficult to see the justification of this extra cost, in view of the small gain in mechanical strength, particularly as the stringent demands of our old war-time friend D.T.D.1000 need no longer be so rigidly adhered to.

It might therefore be suggested that natural silk braid be used in conjunction with a high-grade varnish to produce an homogeneous sleeving possessing very good electrical properties allied to the requisite mechanical strength, for if it is possible to produce such a material in sheet form (from which these sleevings are fabricated) it must surely be within the bounds of possibility to produce it in the form of a braided tube, without having to overcome almost insurmountable obstacles in the processing thereof.

SHOES FROM PLASTICS

Style Restrictions Concession

The total production of shoes in this country is now being slightly increased by the use of fabric-backed P.V.C. (poly-vinyl-chloride) as a supplement to upper leather. Experiments with plastic materials have shown that this material is satisfactory, and supplies are now being distributed to manufacturers. Shoes with uppers made partly from fabric-backed P.V.C. should start to be delivered to retailers early in the New Year.

Shoes of which not more than 50 per cent. of the area of the uppers consists of fabric-backed P.V.C., but which in all other respects comply with the Utility Specifications, may be marked with the appropriate Utility mark and number.

Some shoes containing not less than 33⅓ cent. of fabric-backed P.V.C. in the uppers will be made free of the style restrictions specified for shoes consisting wholly or mainly of leather. Manufacturers who wish to make these shoes free of style restrictions should apply to the Footwear Control at Kettering for the necessary licence.

PLASTICS AND THE GAS INDUSTRY

On going to press we have received a reprinted copy of Dr. De B. Diamond's paper entitled "The Gas Industry and the Plastics Industry" which he read before the Institute of Gas Engineers recently. Of special interest is the inclusion of the discussion that followed the paper.

World's Industry Employs Plastics

ELECTRICAL

Anophoretic deposition from suspensions of vinyl plastic has recently been investigated by Feinleid (Electro Chemical Soc. reprint 88-6, October 8, 1945). Optimum conditions are presented for polyvinyl chloride and polyvinyl-chloride acetate. Applications for this process, which has some similarity to the anodic deposition of rubber from aqueous dispersation of latex, are corrosion protection of metals, insulation of electrical equipment and the production of thin plastic sheets or thin-walled articles of any desired shape or design. **Deposition of metals on plastics** recently investigated by Marcus have been made the subject of further study by this author, who now compares the properties of the plated and unplated bases. (Electro Chemical Soc. reprint 88-5, October 8, 1945). A marked increase in tensile impact and bend strength was shown for many resins as compared with these properties in the case of the unplated bodies. In particular an appreciable increase was obtained in resistance to distortion by heat, whilst by completely enveloping the plastic in a metal envelope water absorption was markedly reduced. General survey of **applications and methods of metallizing non-conductors** is given by Wein in "Metal Finishing," Vol. 42, 1944 (September-December), and Vol. 43, 1945 (January-March). The process is used to increase electrical conductivity, to decrease moisture absorption and indirectly to increase heat resistance. In addition, resistance to surface attack is likely to be lowered and dimensional stability increased, whilst again indirectly impact and compression resistance are both raised, undesirable weathering is controlled and some significant improvements result in flexibility and rigidity. Such plated plastics may, of course, be regarded at the surface as metal bodies; they may be soldered and given surface treatments to obtain special colouring effects. If necessary the use of metal deposits may be employed to increase apparent specific gravity. Problem of **standard nut-type inserts for plastic mouldings** is exhaustively dealt with by Truend in "Machinery" (London), 1945/67/455. Design formulæ and tables of recommended dimensions are given.

GENERAL ENGINEERING

Pipe seals of a new type in plastic art act as protector for the internal thread of pipes; they are provided with either a counter-sink for a pocket spanner or a square head ("Machinery," New York, 1945/52/161). Design factors with respect to **moulded rubber parts** are discussed by Saurer and McWhorter in a very comprehensive account illustrated with isometric sketches. Rubber-metal bonds are also considered ("Machine Design," 1945, July, 17/21). New synthetic so-called **chlorinated Isopol** is available now for use in metal primer formulations and in powder form. It is recommended as a primer for rubber metal bonds, as an ingredient in adhesives, and as an acid and alkali resistant coating for metal and other surfaces ("Machine Design," 1945/17/

170). **Bonding of thermo-setting plastics** by a new process entails the abrading of the surface to be bonded in the presence of a solution of special phenolic resin referred to as bakelite activating solution J11180, after which treatment the appropriate cold-setting cement is applied. Incidentally, it is said that surfaces treated in this way will retain their activity for some weeks. Strength tests have been carried out on cemented components (" Machinery " (London), 1945/67/411). **Diamond dust** of 4 micron particle size is incorporated in lense generating rings produced from Durez phenolic resin and a filler. The rings are moulded in an ingenious method to the body or hub, which is preformed in a moulding compound of high impact strength. Durez Plastics News, 1945/12/2 (July). **Aluminium reflectors** are formed by dies with both male and female sections cast from a Durez phenolic resin (" Metals and Alloys," 1945/22/777). Plastic bearing bushes ready for assembly are the subject of data sheet DIN E 16 902 (VDI Zeit., 1945/88/606). Data on design and production, standard tests at low temperature for plastics are also put forward by the committee on plastics and are recommended in VDI 2,025 (VDI Zeit., 1945/88/606). By utilizing wood veneer waste a new plastic composition has been produced, using the wood filler in the form of chips about 1 in. by 1 in. in size, together with a resin content of about 25 per cent. Best properties are obtained with veneers 0.04 in. thick (Kunststoffe, 1944/34/98). **With woven artificial silk belts** impregnated with acrylic resin (Acronal) and with welded Igamid belts Mintrop has carried out endurance tests in bending up to 100 million stress reversals. The belts were 1 metre long, 1 mm. thick, and 20-30 mm. wide. Fourteen silk belts were investigated using pulley diameters of 30 mm., whilst four polyamide belts were examined using 40 mm. pulleys, belt speeds being 3,600 and 4,800 ft./min. respectively. From the results it appears that varying stresses of more than 350-480 lb./sq. in. cannot usefully be exceeded (Abstract VDI Zeit., 1944/88/526). **Spindle nuts on rolling mills** (VDI Zeit., 1944/88/353). VDI recommendation 2,024 deals with the effects of climatic influence on plastics. Climatic conditions affect materials to varying degrees according to the nature of the basic resin and to the ratio between resin and filler. With respect to fillers, particular care is required in selecting plastics for use in unfavourable climates (VDI Zeit., 1944/88/579). **Wood patterns** can be duplicated at about one-eighth the cost of the original with Durez liquid phenolic casting resin. The technique of the Metal and Alloys Specialities Co., Inc., 1,879, Elmwood Avenue, Buffalo, is described in detail in " Iron Age," Aug. 9/1945/Vol. 165/p. 73. In " Iron Age," July 19 (p. 58), Maris describes the **fabrication of plastic tools,** such as router blocks, forming dies, hydropress form blocks, scriber jigs and mountings for drilling and punching operations.

SHIPBUILDING

New planned production methods in ship construction are likely to be assisted by a recently developed scheme for the preparation of a plastic model of an entire ship to scale, prior to undertaking serious large-scale work on actual working drawings or on the job itself. Such a system is outlined in " Welding Journal," 1945/24/347. The use of a model in this way allows for speedy and accurate planning of all parts and tends greatly to assist the building programme. **Phenolic materials** and methods of boat-building are yielding to the newer plastics; advantages offered by latest developments are resistance to corrosion and fungi, ease of working and high strength. In " Scientific American," 1945/173/210 (October), the application of paints, plywoods and laminated wood is comprehensively dealt with and illustrated.

AIRCRAFT

Phenolic fibres, i.e., cotton-base laminates impregnated with phenolic resins belong to a very important group, principally developed during the war years and which seems to have a promising future, too, in many fields. Stedman discusses their characteristics, design features, fabricating behaviour, etc., from experience gained in several B.25 bomber components (" Metals and Alloys," 1945/22/1658).

MISCELLANEOUS

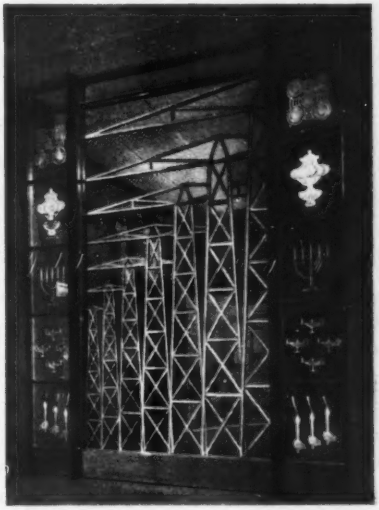
Transferred moulding permits the application of thermosetting plastics to the realization of many designs which cannot satisfactorily be moulded by normal compression methods. Buchanan considers this technique in detail in " The Machinist," 1945/89/799. Capacities and general design features of **hydraulic presses for moulding of plastics** are discussed in a review of the principal types of Chartrand, of the Plastics Division of G.E.C., in " Machinery," New York, 1945/52/172. On page 206 of the same journal it is noted that a thermosetting resin has been recently developed for impression moulding. A fabric or paper is suitably impregnated with a resin and covered with layers of filler, the whole being draped over or into a mould. By backing the composite under very low or even merely under its own weight at about 100 degrees C., a durable product is obtained. The Tharlid X500 material of Monsanto has proved useful for this purpose. **For sealing plaster moulds** used in casting plastics and other materials Vultee Aircraft Corporation have made use of a resin-base thermosetting compound; it is applied by spraying or brushing and dries in 3-4 hours. Reports seem to indicate that it is superior to the lacquers hitherto commonly used in plaster moulds. In order to obtain castings with high gloss the basic coat of sealing compound is sanded and afterwards recoated. The material resists temperatures up to 250 degrees F. (" Iron Age," 1945, September 13/156/540. **Survey of commercial thermoplastic synthetic resins** is presented in a data sheet giving composition, strength, heat resistance, resistance to attack by acids and alkalis, water resistance, possibilities of colouring, trade names and typical uses of the different plastics are listed. (" Metals and Alloys," 1945/22/451.) General account of the **phenolic resins,** still the most widely used group and at the same time the first wholly synthetic resins of reasonable heat resistance, is given by Henry in " Purchasing," 1945/18/75. **Data sheet on the thermosetting of plastics,** divided into three types of phenolic and four types of amino plastic lists tensile strength, Rockweel hardness, water resistance, heat resistance, specific gravity, resistance to acids and alkalis, possibilities of colouring, trade names and uses. (" Metals and Alloys," 1945/22/133.) **Preparation of polished thin sections of minerals and ores** often entail some difficulty as the Canadian balsam traditionally used is not too satisfactory in its resistance to machining stresses, etc. Thermoplastics, such as glycol phthalate and polyvinyl acetate. (" Economic Geology," 1945/40/353.) Forming of brush backs, knife handles, knobs and other utilitarian parts in impregnated and moulded solid wood is described in " Scientific American," 1945/173/212. The advantages claimed for this technique are that the appearance of the natural wood is retained, whilst resistance to water, acids and alkalis is conferred both in the cold and hot state. **Defiance plastic moulding press** integral with compression chamber is described in detail in " Machinist," 1945/89/990. Data sheet on rubbers has been included.

Women's Electrical Exhibition

BECAUSE the particular virtues of plastics were so early recognized by the electrical industries, it is not surprising to find that at the first Women's Electrical Exhibition (staged recently at Dorland Hall by the British Electrical Development Association for the 21st Birthday Celebrations of the Electrical Association for Women), the synthetic resins were well represented.

In these few brief notes, however, it is not proposed to discuss the use of plastics in electrical engineering science, but rather to comment on the uses made of them in the domestic field and in purely artistic spheres as exemplified at this Exhibition; more especially will attention be directed to the significant use made of plastics in combination with the light metals.

In this journal we have, for many years, stressed the importance of using plastics in conjunction with other modern structural materials in order that the fullest possible value may be educed from them. Hulme Chadwick, A.R.C.A., A.R.Ae.S., the designer of the Exhibition, brought into full prominence the issue of these two complementary aspects and, side-by-side with masterpieces of industrial art in plastics, he linked up products of skilled design and craftsmanship, the effect of which might justly be said to



Screen—Spirit of Electricity—designed by Ralph Lavers. The panels are engraved in massive "Perspex" sheets.

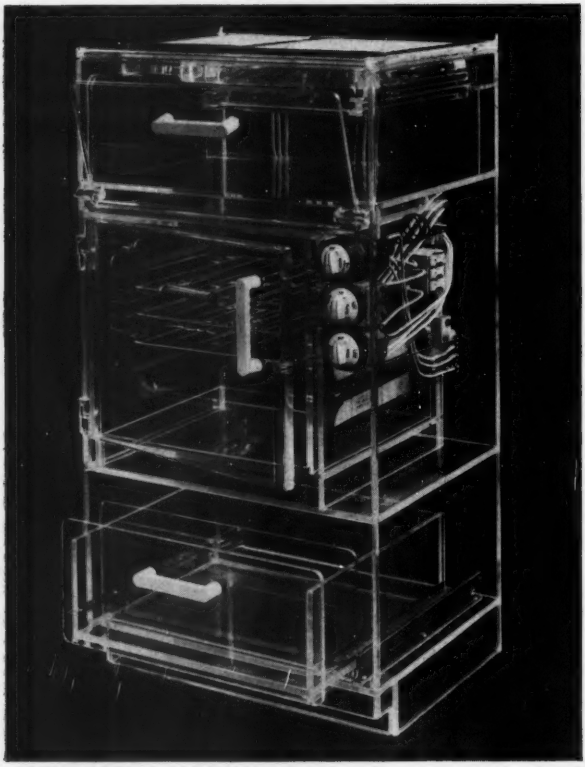
materials Vultee Aircraft Corporation on rubbers has been included.

have been due almost entirely to aluminium and "Perspex" working as a team.

One of the most striking examples evolved by Chadwick's co-workers was the aluminium grille with "Perspex" panels, designed by Ralph Lavers and executed by J. Starkie Gardner Ltd. In this grille, which is some 15 ft. high and 12 ft. wide, may be seen, flanking the symbolic representation in aluminium of electrical energy, a series of engraved panels in "Perspex," depicting in highly imaginative forms the multitudinous uses of electricity. The panels are of massive gauge, finely engraved to give the full light-dispersion effect of the material.

The "careers" panel, which is of curved form, consisted, again, of a series of "Perspex" panels, $\frac{1}{8}$ in. thick, depicting careers for women in the electrical industry. The views shown were produced by photographing direct on to the sensitized material. In this instance the panels are mounted on a screen, the body of which consists of expanded aluminium, anodized and dyed to a golden colour.

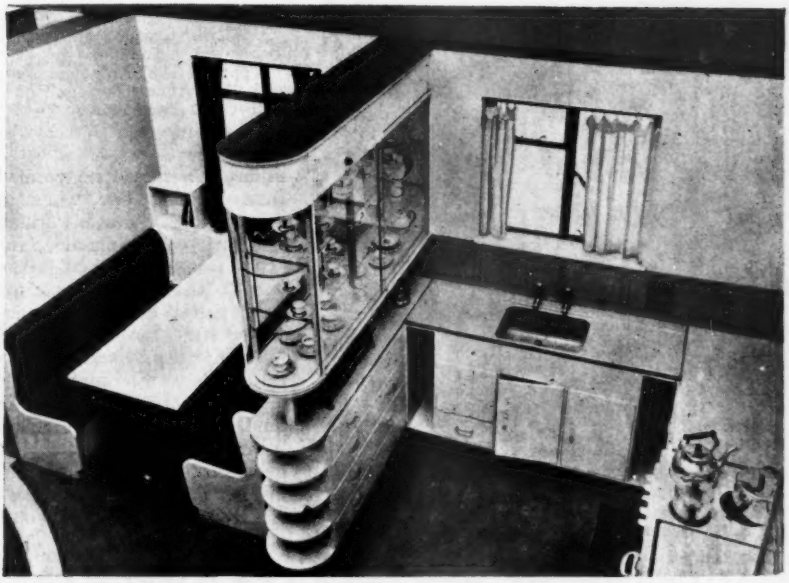
Naturally enough, popular interest centred principally on the all-electric kitchen, the significant components of which were constructed almost entirely of "Perspex," with the combined use of aluminium where necessary for structural reasons. Accompanying illustrations of this kitchen will serve better than mere words to demonstrate how the peculiar advantages, especially as regards workability, of plastics were turned to account here. Thus, the curved "Perspex" glazing in the china cupboard, relatively simple in execution, would have entailed



Full scale model of Jackson electric cooker. Apart from the electrical circuit here, the whole of this assembly was executed by J. Starkie Gardner Ltd., in transparent "Perspex" sheet, assembled by dovetailing and grooving. It should be pointed out that whilst this is a working model, it could not, of course, be used in practice as the polymethylmethacrylate resins are not suitable for use at high temperature.

side-by-side with masterpieces of indus-

in massive "Perspex" sheets.



View of the plastic kitchen showing china cupboard with curved front "glazed" with "Perspex," table top and settee sides in fawn opaque "Perspex" and splash-back and work bench top in blue opaque "Perspex."

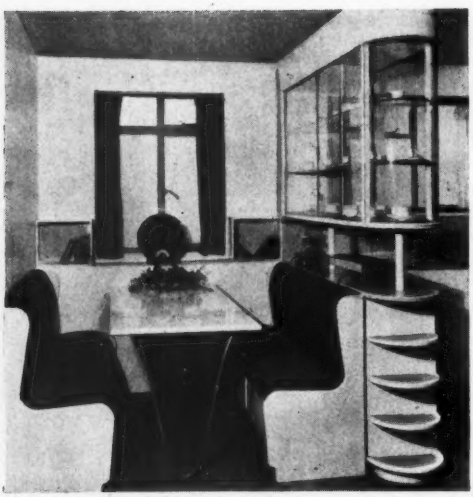
in the case of plate glass not only considerable technical difficulty, but, furthermore, very high working costs.

Of the individual items in the kitchen, the "splash-back" and work-bench top were in blue-coloured opaque "Perspex." The roller-front fitted to the kitchen cupboard was made of clear "Perspex" rods backed with dust-proof "Bexoid" sheet and fixed to an aluminium roller; cupboard handles were all of clear "Perspex" with a moulded-in brass ferrule for fixing.

The top of the table in the dining recess was in pale-fawn opaque

Typical example of lettering used to identify the exhibits. That shown here consists of cut-out letters in coloured "Perspex" fixed on to a clear sheet of the same material.

The careers panel, which is of simple in execution, would have entailed



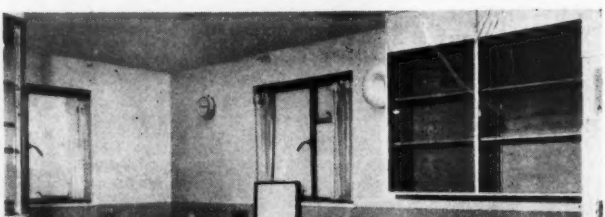
View of dining recess, showing table with opaque "Perspex" top and aluminium section support. The settee sides are also of opaque "Perspex" on sandwich board.

"Perspex"; this material, suitably framed on to a sandwich board, being used also for the sides of the settee. The table support was formed from extruded aluminium section.

Finally, curtains were in "Welvic" (P.V.C.), which, of course, is easily cleaned by mere sponging down, does not readily hold or trap dust and will not absorb grease.

Amongst the more spectacular exhibits was the full-sized model (by J. Starkie Gardner Ltd.) of an electric cooker, of which the entire structure, apart from the electrical elements, had been executed in clear "Perspex" sheet assembled principally by dove-tailing. It should be pointed out, of course, that, whilst in one sense this was a working model, it was not intended for actual use, inasmuch as "Perspex" itself is not suitable for employment within the high-temperature range called for here. Its purpose was solely to demonstrate the construction and mode of operation of the unit. At the same time, apart from this, the model did demonstrate in a very striking manner the constructional and artistic possibilities of this particular plastic.

Use was also made of "Perspex" in connection with the identification of the various bays. Thus, that devoted to communications and headed with the inscription "Communications," featured this last word in cut-out clear "Perspex" letters, the edges of which were painted. Other bays were identified by means of inscriptions built up of letters cut from coloured "Perspex" sheet fixed to a clear backing of the same material.



Further view of kitchen, showing, at the right, roller-fronted cupboard together with splash-back and work-bench top in blue opaque "Perspex."

same material.

Lining Tanks with Vinidur*

The lining of metallic, wooden or concrete tanks and containers for the chemical industry has proved very successful. Such tanks have been in continuous use for a variety of chemicals at temperatures up to 50° C. and have given full satisfaction. This paper describes the lining technique which differs according to the material of the container. (1)

VINIDUR films used for surface protection are made of Igelite P.C.U. For the manufacture of these films Igelite powders are milled on roller mixers until plastic, and subsequently calendered. Since the material is passing through the calenders for only a comparatively short period, very little time is allowed for warming up; this limits the thickness of the film that can be produced. If the film thickness exceeds 1 mm. there is a tendency for surface wrinkles to be produced. Such faulty (wrinkled) films can only be fixed with difficulty to the inside of a tank and are the cause of air pockets. It is therefore recommended to use films thinner than 1 mm.

On the other hand, thickness limits are also imposed by the mechanical properties of the material at the somewhat elevated temperature required for the lining process and films which are too thin cannot be used. Satisfactory corrosion protection may be obtained using material only 0.4 mm. thick, but as it is rather difficult to avoid damage to such thin films during the lining process, and as the saving in material is quite small, films of at least 0.7 mm. should be used in practice. Experience has shown that the best results are obtained with films measuring 0.8 to 1 mm. Within this range lap-welding can be carried out without difficulty.

Vinidur film is available in standard rolls 0.7 metres wide, varying in length from 4 to 20 metres.

* By A. Sirot. Translated by G. Haim. The original article was published in Kunststoffe: Vol. 33 (1943), No. 2, pp. 33-39.

Lining Metallic Containers

Success in lining can be expected only when the recommendations given below are strictly followed.

Nearly all metals can be lined with Vinidur, the exceptions being lead and some of the light alloys for which the temperature of the lining process (approximately 130 degrees C.) has a detrimental effect on the mechanical properties. In the case of containers which have been previously lined with lead, it is necessary to remove this lining by burning and subsequent sand blasting.

The shape of the container is immaterial, and it is only required that parts to be lined should be accessible from all sides.

The best results are achieved with containers having a wall thickness between 4 and 8 mm., as enough heat can then be stored during the warming-up to effect proper de-aeration of the cement before the film is attached. For thinner walled containers, additional heat may have to be provided during the lining operation; this complicates the process considerably. In the case of containers made of sheets thicker than 8 mm. there is danger of overheating and possibly destroying the cement; heating up should, therefore, be gradual and large areas should be heated simultaneously.

Riveted tanks are unsuitable for lining with Vinidur, as stretching of the film which is necessary to cover the heads of the rivets may cause stresses, which will eventually lead to cracks or fissures if considerable fluctuations in temperature occur. In the case of riveted containers not subjected to pressure, it is permissible to cover the riveted seam with a strip of metal, which must at the same time cover the metal overlaps in the container, and it is obvious that it should be over-welded along its full length and not just tacked. Another method which may be adopted for riveted containers is by covering

the rivets with a layer of concrete approximately 5-7 cm. thick before lining with Vinidur. Welded tanks are preferable to riveted ones when subsequent lining is contemplated.

Tanks to be lined should be designed with sufficient strength to prevent distortion; when using thin gauge sheet stiffeners should be provided. Slight deformations of the walls which occur during the filling or discharging of the tank have no detrimental effect on the Vinidur linings. Lined tanks or containers should, however, not be subjected to continuous vibrations, as they cause detachment of the film from the inside walls. Where such continuous vibrations occur an elastic interlayer should be provided between the foundations and the container proper.

Preparation of Containers for Lining

To achieve proper bonding of film to metal the latter should be carefully prepared. Grooves which frequently occur with flanges and sockets should be filled in by welding.

Welded deposits should be thoroughly cleaned from all dirt and oxides, and wherever possible roughened up to improve adherence. In the case of steel tanks this can easily be achieved by sand blasting.[2] A suitable material for sand blasting is quartz sand; shot, of a size of 2-4 mm. is even better. It is blasted against the walls under a pressure of 5-6 atmospheres; unsieved sand is unsuitable.

Other metals, for instance, copper and aluminium, may also be cleaned and roughened up by sand blasting, provided proper care is taken. The degree of roughness required compares with the appearance of emery paper Nos. 3 and 4. Light alloys are much more readily attacked by sand blasting, and should preferably be prepared by a chemical treatment. For this the metal is first cleaned with a suitable solvent for fats, e.g., carbon tetrachloride or trichlorethylene, to remove all oil or grease from the surface. A solution containing 30 per cent. sodium hydroxide, 10 per cent. oxide and 60 per cent. water is then applied to the clean surface with a thick rag, care being taken that the whole surface is uniformly coated. When the surface is covered with a uniform layer of zinc the solution is washed off and the surface dried. This treatment should not be extended over too long a period or a spongy coating will result. Anodized tanks are well suited for lining with Vinidur. Alloys containing a large percentage of magnesium should be treated with a 1 per cent. solution of aluminium chloride after de-greasing.

After sand blasting the metallic surface should be cleaned by means of a

Fig. 1 (above).—Testing Vinidur lining with a spark gap inductor.

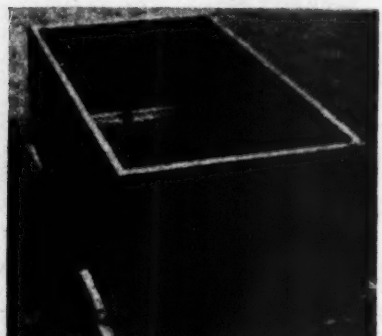


Fig. 2 (right).—Wooden container lined with Vinidur film and clad outside with sheet.

hair brush and all dust blown off by compressed air as a vacuum cleaner. Insufficient cleaning results in bad bonding.

Sand-blasted surfaces reoxidize rather quickly, the first coat of the bonding solution should, therefore, be applied immediately after cleaning and sand blasting.

Application of the Cement

P.C.10 solution is used as a cement, the viscosity of which should be sufficiently low to allow proper penetration into all pores and voids of the metallic surface. Solvent vapours evaporating from this cement are intoxicating, and proper ventilation should be provided to minimize detrimental effects to the health of the workmen. This is easily achieved by a fume exhaust, but as the vapours are heavier than air, care should be taken to insert the exhaust tube at the lowest part of the container. Work on pressure tanks should only be permitted where gas masks can be provided, even then all solvent vapours must be removed by exhausts.

The careful and appropriate application of the P.C.10 solution is of great importance, in achieving satisfactory results. This solution should be of the right consistency and, what is even more important should be applied very uniformly. This can best be carried out by brushing on several coats of a solution of rather low viscosity. When the last coat is dry the entire metallic surface should be covered by a smooth, shiny film. If this is not the case a further coat should be applied. The consumption of P.C.10 varies between 1.3 and 1.5 kgs. per square m. Between the first and second coat a drying time of 1-2 hours should be allowed and the last coat should dry for approximately 15 hours. Coatings which have been left unattended for more than two days prior to the commencement of the lining process show a tendency to discoloration when degassing takes place, and this can only be attributed to decomposition of the bonding solution. In cases where lining cannot be carried out within the time limits stated, it is advisable to apply a further coat of P.C.10, preferably mixed with methylene chloride in the proportion of 1 : 1. This results in a softening up of the previous coatings and permits better degassing. When applying the cement, care should be taken that the brush is properly soaked; superficial wetting is not sufficient. Brush marks and tears should be avoided, which is best done by pressing the brush firmly into the cement. Large-size round brushes of 50-70 mm. diameter, made of bristles (approximately 50 mm. long) are best suited for this process.

The bonding action of P.C.10 cement is not due to film formation, but to the artificial resin which it contains.[3] To avoid formation of bubbles underneath the lining, thorough degassing is required before application of the film. (Gas bubbles are the result of evaporation of the solvent.)

Degassing is effected by heating the container from the outside up to a temperature of approximately 130-140 degrees C. It is easy to watch the progress of degassing as small gas bubbles appear in the film, which becomes opaque, silver grey in colour, and takes on a foam-like structure. Once the formation of new gas bubbles has ceased, degassing can be considered as complete. At this stage the film acquires the correct plasticity. If the above-mentioned changes do not take place, or if a dark grey colour instead of a silverish grey one appears, it can be taken as a sign that the solution has been applied too sparsely. A further coat of P.C.10 after cooling will cure this fault. Overheating of the film can be recognized by discoloration and should be avoided, or the film will lose all its bonding properties. The speed of decomposition increases considerably with increasing temperature, and at 180 degrees C. decomposition takes place almost spontaneously. With some experience, however, it is not too difficult to degas the film without overheating.

The warming up to 130-140 degrees C. is necessary to remove all the solvent from the cement, and to plasticize the dissolved plastic. This temperature is also required to keep the Vinidur film soft

and pliable, so that it can cover all the uneven parts on the metallic surface.

Preparation of the Vinidur Film

The film is brushed thoroughly with P.C.A.20 solution before being attached to the metal; care should be taken that P.C.10 and P.C.A.20 are never mixed up since their action is entirely different. All dust is removed from the film with a duster free from dust. Oily or fatty surface films should be removed with methylene chloride; washing with methylene chloride, however, is not necessary, as the film is clean as supplied and can be worked without any chemical pre-treatment. A single coat of P.C.A.20 should be applied evenly and without brush marks, the consumption per sq. m. being approximately 0.3 kg.

The application of P.C.A.20 to Vinidur film sometimes results in hardening of the film. This, however, is not detrimental as the film softens again in the course of warming up. The cutting of Vinidur film should be carried out before it is painted with P.C.A.20 as the rather brittle film has a tendency to crack when cut to size. P.C.A.20 requires a drying time of approximately 15 hours and should be applied one day prior to lining.

Details of the Bonding Process

Practically all types of welding torches are suitable for preheating the metal, provided the length of the flame can be controlled. Hydrogen is especially suitable as heating gas as torches with regulator valves can be used and additional air is not required for combustion, but practically all the gases used for welding can be applied to this process.

Preheating of the metal to at least 130 degrees C. is necessary for proper degassing and application of the film. It is recommended to follow up with the lining process immediately after degassing, i.e., only to degas at any one time, such portion of the total area as can be kept sufficiently hot to allow immediate application of the film. The exact area, however, depends entirely upon the heat capacity of the container (determined by the thickness of the metal). At the usual thickness of 5-8 mm., with a smooth inside surface, pre-cut films of 0.5 to 1 sq. m. can be degassed and lined without any difficulty in one operation.

Vinidur films are detached from the calender while still warm and plastic. Consequently the film becomes stretched and when it is warmed up later it shrinks to approximately the same degree as it was previously stretched. The degree of shrinkage in the direction of calendering amounts to approximately 3 per cent., whereas practically no shrinking occurs at right angles to the direction of calendering. This particular property of Vinidur film has to be taken into account when lining and the film should only be applied in the direction in which it was calendered so that it can shrink in the course of lining.

The bonding operation is comparatively simple. Due to the radiation from the metallic surface the Vinidur film becomes plastic and can easily be pressed on to the metal with a soft rag or a felt roller. Starting from one end and progressing slowly the film is applied to the surface until its whole length is attached. Stretching of the film during this operation should be avoided and slight brushing only may be carried out once the film is properly fixed to the base.

THE LINING PROCESS

Lining Small Containers

In the case of smaller tanks it is recommended to start first by lining the base, at the same time applying the film to approximately 20-30 mm. up the sides. A wooden spatula may be used to press the film into corners and edges. Those parts of the film which extend over the bottom are kept carefully away from the sides so that they do not stick prematurely. They should only be fixed to the sides when all the corners have been properly lined. In the case of cylindrical containers the film required for lining the base must have a diameter at least 40-50 mm. larger than that of the base; overlapping and subsequent undulations may occur and in many cases the heat radiated from the walls is not sufficient

to keep the film plastic. A very soft flame should be carefully applied to that side of the film which has not been treated with cement and the film can then be pressed on to the preheated wall. Although the Vinidur film has to be stretched slightly this should present no difficulties as it is in a soft and plastic state. Folds should be avoided, but if they have already occurred they should be cut out with a warm knife or removed by rasping. Once the bottom surface has been lined, the sides can be covered with the film.

Lining Large Containers

Lining of containers which are not more than 6 ft. high, can be carried out in the same way as already described. One of the conditions, however, is that the lined base is kept clean and that heavy boots are not worn by the operators. In cases where scaffoldings are used, for instance in very high static tanks, the base should only be lined after removal of the scaffolding, which means that the sides must be lined first. The lower ends of the film covering the sides are left unattached, then the base is lined, with the film extending slightly up the sides, and finally the ends previously left loose are attached to the base.

The lining of a horizontal tank presents no difficulties, as it can be put on rollers and rotated, thus making all parts accessible.

When lining very large containers good communications should be provided between the man working inside and the operator carrying out the preheating from the outside. In cases where the two men cannot communicate directly a third man should stand by to direct the work. It has been found quite useful to subdivide the outside of the container into small areas, denoted by figures or letters, so that the operators can communicate their wishes by megaphone.

The lining of the sides of round containers is best carried out by starting from the lowest edge and progressing upwards. A circular arrangement of the film is not very practicable, as it stretches easily when it becomes plastic; apart from this, it can only be shrunk with difficulty. In the case of rectangular containers the film is slightly bent in the corners and pressed well home by means of a wooden spatula. It has proved useful to abut the film at corners and to overlap it at an angle with another film approximately 60 mm. wide. The corners remain thus uncovered and are lined with a prefabricated corner piece.

Lining Flanges and Sockets

No difficulties are encountered in the case of sockets sufficiently wide to allow lining by hand. Narrow flanges are lined by inserting and cementing in a Vinidur pipe previously plasticized by heating. The outside diameter of this pipe after heating should be slightly larger than the inside diameter of the socket. Flanges are lined with a ring of Vinidur film bent towards the inside of the container by application of direct heat. It is not recommended to line the inside of the flange first and then to progress outwards.

Lining in Sections

Tight seals between the individual layers can be obtained either by overlapping or by welding of the closely butted film.

The width of the overlaps should be approximately 30 mm. It is advisable to clean the previously laid Vinidur sheet with methylene chloride before applying the next sections. Three coats of P.C.10 cement are required. After careful degassing from the outside the covering film is applied in the manner already described. Cleaning with methylene chloride and brushing on of the P.C.10 should only be carried out when the metal is already quite cold, otherwise the cement will not stick properly to the Vinidur. In cases where overlapping is used, the free edge can be overwelded with a Vinidur filler rod (approximately 1.5 mm. thick).[4] For containers which are subjected to repeated mechanical stresses, such as are caused by stirrers, or for tanks containing liquids which chrystallize, welding has to be carried out in any case. Prior to welding all traces of P.C.10 must be removed

first by washing with methylene chloride and finally by means of a scraper. The welded seam should be dressed with a tool specially developed for this purpose in order to produce a smooth surface.

In the case of plain butts, the film has to be cut so that the gap between the individual sections does not amount to more than 2 mm. The edges of the sections are then bevelled with a suitable tool and the space between them is filled in by welding with a Vinidur rod approximately 3 mm. thick. Where necessary more than one weld may be deposited. The welds are then dressed and tested with an inductor, all places found to be unsound being again overwelded. Finally the dressed weld is covered with a film 10 mm. wide and 1 mm. thick, also by means of welding. The final testing is also carried out with an inductor.

Testing

All tank linings should be tested immediately after fabrication, as the film may have been damaged in the course of bonding through the dropping of tools or other accidents. Testing should take place whenever a tank has been moved, either for transport or otherwise, but in any case immediately before taking it into use.

The simplest method of testing is by means of a spark gap inductor, which detects even minute pores. The gap should be set to give a spark length of 12-15 mm. Testing of a lined container with an inductor is shown in Fig. 1.

One of the terminals of the inductor is connected to the metallic body of the container, the other to a testing brush by means of a welding cable. After starting the inductor the operator moves the brush all over the lining and whenever a spark is noticed keeps the brush on this unsound spot for a short while, so that blackening takes place due to decomposition of the film.

Where electric testing gear of this kind is not available chemical tests as used in the enamelling industry can be applied. For this purpose the outside of the lining is brushed over with a 5 per cent. sodium chloride solution containing phenolphtalein as indicator and a small amount of a wetting agent. The tank is then connected to one terminal of a high-tension battery of approximately 120 volts and the second terminal to a small tool with insulated handle, the other end of which bears a sponge soaked in indicator solution. Unsoundness of the lining is revealed by red marks from the indicator. The battery should be replaced once its voltage drops below 90 volts.

Repairing Faulty Parts

Unsound parts can be repaired by patching up with Vinidur. For very small defects it is sufficient to clean the vicinity of the faulty part with methylene chloride, and to brush it over with bonding solution. The latter is then degassed and covered with a patch of Vinidur coated with P.C.A.20 solution.

Larger defects due to overheating must be cut out with a heated knife. The cement underneath is then removed by scraping and washing with methylene chloride and a new coat of P.C.10 solution applied together with a patch of Vinidur film extending more than 30 mm. all around the hole; welding around the circumference of the patch with a Vinidur rod (1.5 mm. thick) is recommended. Air trapped between the metallic body of the container and the film should be released by drilling a hole of approximately 5 mm. diameter into the film; the area around the loose part is then warmed up, the Vinidur sheet pressed against the metal, and the hole is covered by a Vinidur patch. Loose parts can easily be recognized by tapping, as contrary to parts which have been properly bonded, they do not resound metallically.

Lining of Steel Pipes

Vinidur pipes have often been inserted into steel pipes where high pressures are applied. This, however, is not to be recommended, as the slightest rise or fall in temperature causes cracks in the Vinidur pipe, as the thermal expansion of Vinidur is approximately seven times as great as that of steel. Steel pipes, preferably seamless, with a diameter greater than 400 mm., can be lined with Vinidur film without difficulty. The method of

application is the same as already described.

Whereas in the past only comparatively short pipes of not more than 1 metre length and 150 to 500 mm. diameter have been lined, a process has been developed within the past few years permitting the lining of pipes of somewhat greater length. This lining process, however, requires a certain amount of experience with Vinidur and should, therefore, only be carried out by specially trained workmen.

The inside of the steel pipe is first cleaned by sand blasting to provide a rough surface. Then P.C.10 solution (diluted with approximately 50 per cent. methylene chloride) is poured over the surface. During this operation the steel pipe is held in an inclined position and continuously rotated to permit even distribution of the cement; at the same time the pipe is heated up from the outside for degassing. Simultaneously, a cylinder of P.V.6 film is prefabricated, care being taken that its outside diameter is approximately 2 mm. smaller than the inside diameter of the steel pipe; it should also be 20 cm. longer than the steel pipe. The fabrication of the P.V.C. cylinder is preferably carried out by forming the film over a steel pipe (heated by steam) and cementing the P.V.C. where it overlaps. After coating the Vinidur cylinder with P.C.A.20 solution it is introduced into the steel pipe, which is now cold, and finally attached manually as far as possible. The flange is lined in a similar way. When this is done a blind disc attached to a short piece of pipe of approximately ½-in. width is screwed on to the flange. The P.V.C. cylinder is then sealed at the other end by a Vinidur disc. Lining proper can now be started. The elbow piece is connected to a compressed-air pipe and the P.V.C. cylinder exposed to a pressure of approximately 1.3 atmospheres. This pressure should not be exceeded, as there is a danger of bursting the P.V.C. cylinder in the course of warming up, and it is recommended that the pressure be controlled with a pressure gauge. The steel pipe is then slowly heated up from the outside by means of a gas burner (ring type), the diameter of which should be approximately 150 mm. larger than the outside diameter of the steel pipe. Temperature control may be achieved with temperature-indicating colours brushed on to the outside of the steel pipe. (The grade recommended by the author is No. 4 of the I.G. Farbenindustrie colours, which changes from purple to blue at 140 degrees C.) In the same measure as the steel pipe heats up the Vinidur film softens and sticks to the pipe. To avoid air inclusions, heating up should be slow so that air remaining between the steel pipe and the Vinidur cylinder may escape. Whilst warming up, the steel pipe is continuously rotated to permit uniform heating; once the lining process is finished the pipe is allowed to cool under pressure, and finally the end of the pipe as well as the flanges are lined by hand. The P.V.C. cylinder stretches during the lining process and increases by approximately 5 per cent. in length.

Elbows and Tee-pieces cannot be lined by this process, but must be lined manually. Faultless lining can only be performed where the leg length of the elbow does not much exceed the pipe diameter.

Lining Containers Made of Wood and Concrete

The lining technique for containers made of wood or concrete differs from that used for metallic vessels, as it is impracticable to heat such vessels from the outside. Cementing in this case is not achieved by heat softening of the P.V.C. film, but depends entirely on the sticking capacity of the cement, e.g., the film formed by it. P.C.13 AM cement used for lining wooden and concrete tanks contains, apart from highly volatile solvents, some others which volatilize rather slowly. These latter can only be evaporated if the material of the tank is somewhat porous, which is nearly always the case where wood is used, but with concrete the right porosity is only obtained by proper composition of the

concrete, e.g., selecting the right grain size of the sand.

Vats made from wood or concrete can be lined with Vinidur film irrespective of their size. It is, however, necessary to specify certain limits with regard to the proper choice of material, and to consider certain constructional details.

Green wood has a tendency to shrink in the course of drying out, and this may lead to serious fissures, as the Vinidur film cannot shrink in the same measure as the wood; care should be taken that only well-seasoned wood is used. In addition, the wood should be free from resins and should not contain knots, as these will protrude in time and damage the P.V.C. film. Woods rich in resin, such as pitch pine and Bosnian fir, which are quite commonly used for making vats, are too dense and do not permit proper adhesion of the cement. The best materials found so far are beech and gabboon plywood, which fulfill practically all these requirements. Already existing vats made of wood rich in resin can be prepared for lining by nailing on a plywood sheet approximately 5 mm. thick.

Treatment of Concrete

Concrete containers should be constructed along certain lines and the composition of the concrete be considered where lining is contemplated. Ferro-concrete is preferable as it is less liable to cracks and shrinkages. Two layers of plaster each approximately 20 mm. thick should be put on to the concrete. This plaster should be free from lime, otherwise the cement will not adhere. A recommended composition is one part (vol.) of concrete to two-three vols. of sand, the grain size of the latter being between 0.5 and 3 mm. The plaster is applied to the underside by means of a small board, using circular motions. A trowel should not be used, as the surface of the concrete would become too smooth. Once the plaster has dried properly, it should be roughened up with a carborundum disc.

P.C.13 AM cement is applied three times to the perfectly dry underside of the wood or concrete; according to the roughness of the surface 1.5-1.8 kilograms per square metre are required. The first two coats are applied the day before lining is to take place, with an interval of approximately one hour between the first and second coat; the third coat precedes the actual lining only by a very short time, and is allowed to dry just sufficiently to be no longer sticky to the touch. Then the P.V.C. film, with P.C.A.20 solution brushed on is applied to the underside, warmed up with a soft flame from the uncoated side, and finally pressed on and fixed. (The film should be perfectly soft when pressed on.) For the lining of wooden or concrete containers it is recommended to preshrink the P.V.C. film before sticking to avoid subsequent shrinking which will cause cracks. The P.V.C. film should be applied in the direction of calendering, although this is not so essential as in the case of metal tanks. Stretching caused by brushing should, however, be avoided.

Jointing between P.V.C. films should be carried out by overlapping and not by abutting, the width of the overlaps being approximately 30 mm. Overlapping may be effected by cementing after cleaning with methylene chloride, subsequent brushing on of P.C.13 AM solution and pressing on of the plasticized film. Overwelding of the edges by means of a welding rod (1.5 mm. thick) can also be carried out. A few days should elapse between lining and welding to enable the solvent to penetrate into the material of the container and to volatilize.

Wooden or concrete vessels lined with Vinidur can be put into use immediately after lining, provided the liquid which they are to hold is cold. For warm liquids an interval of approximately two to three weeks should elapse. Fig. 2 shows a photograph of a wooden container lined with Vinidur.

Limits to the Use of Vinidur Linings

Vinidur linings have proved a success when used for carrying chemicals at temperatures up to 50 degrees C. Exceeding this temperature for a short time, even

up to 70 degrees C., has no detrimental effect, but continuous use at temperatures higher than 50 degrees C. should be avoided under all conditions. At temperatures below zero Vinidur becomes rather brittle and cracks, especially under mechanical stress, but cases are reported where Vinidur-lined tanks have stood for years at temperatures as low as − 30 degrees C. in the open; repeated freezing of the acid which they contained did not impair the excellent quality of their lining. They can, therefore, be recommended for temperatures down to − 10 degrees C.

Abrasion Resistance

The abrasion resistance of Vinidur approximately equals that of copper. Vinidur linings may, therefore, be used for tanks in which liquids are agitated by mechanical stirrers. How far Vinidur is suitable for tanks in which suspensions are stirred depends entirely on the speed of stirring and the hardness of the particles in suspension. Generally speaking, inorganic and organic salts do not attack Vinidur provided that all joints made by abutting or overlapping are sufficiently smooth. Mechanical cleaning of Vinidur-lined containers is permissible if proper care is taken (e.g., soft brushes are used and nailed boots are not worn by the workmen walking inside the vessels).

Vinidur linings can be applied to storage bins, water purification plant, and reaction vessels. In the metal industry such linings have been used for pickling and plating tanks. Obviously the process can also be successfully applied for the production of food containers.

Lining of Containers With Vinidur Sheets

Where mechanical stresses are likely to be considerable or thermal conditions severe, containers should be lined with Vinidur sheets instead of film. Generally speaking, sheets between 3 and 5 mm. thick are used, but for resistance against extreme mechanical stresses even thicker sheets can be applied. Comparatively small vessels so lined will withstand temperatures up to 60 degrees C., under continuous use and short time heating up to 100 degrees C.

The Vinidur sheets are not fixed to the inside of the container but form a loose insert. Vinidur sheets, too, have the property of shrinking when heated, and the liner should, therefore, be preshrunk in an oven at 130 degrees C.

Lining with Vinidur sheets is independent of the material of the container, but it is, however, important to make the linings sufficiently strong. The fabrication of inserts for straight containers is easy, it becomes rather complicated, however, where the walls of the vessel are curved. Up to the present time only comparatively small vessels have been lined by this process. In the case of large-size containers, being continuously filled and emptied, stiffeners should be provided to prevent warping of the sheets.

The fabrication of such inserts is conveniently carried out away from the containers by welding up the Vinidur sheets. It is advantageous to vee the sheets and to reinforce the root; owing to the curious properties of Vinidur under heat, proper play should be allowed in every direction. For rectangular containers the sheets may either be bent when warm or edge welds should be used; the latter course being preferable as the bent Vinidur will take its original shape when reheated, which will have a bad influence on all the adjacent welded seams. For the fabrication of round containers the sheets should be preheated and bent. Flanges should be covered with a Vinidur ring which is then joined to the walls by welding.

REFERENCES

(1) *The whole subject is extensively discussed in a book by Sirot: Plastics for Corrosion Protection, Handbook for Vinidur and Oppanol, published by J. F. Lehmann, Muenchen and Berlin,* 1943. *See also VDI* 2009: *Lining with Plastic Films.* (2) *H. Klant: The Installation of a Plastic Workshop; Kunststoffe, Vol.* 32 (1942), pp. 307-310. (3) *A. Petz: Recent Plastics Used in the Glue Industry; Kunststoffe, Vol.* 32 (1942), pp. 49-54. (4) *A. Henning; The Welding of Thermoplastics: Kunststoffe, Vol.* 32 (1942), p. 103.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

THE SHIPTON INJECTION MOULDING MACHINE.—This is an improved machine designed primarily for the production of mouldings from polythene and similar plastics. It is claimed to achieve a big range of capacity from zero to 20 oz., thus emphasizing its extreme versatility.

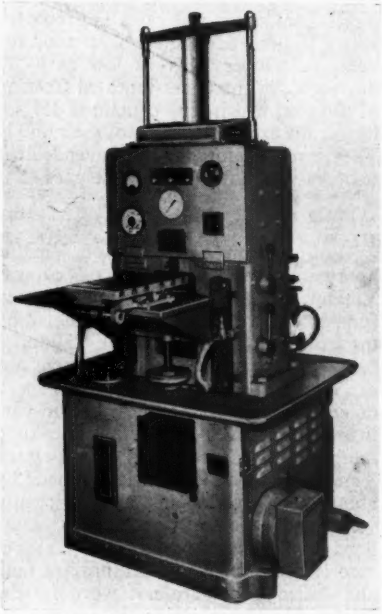
Other points of interest are that non-ferrous moulds can be used enabling small quantities to be economically produced. Moreover, it has two nozzles, so that two operators can work on the machine at the same time.

Its compact size and perpendicular build effect a great saving of floor space, the overall dimensions being only 3 ft. by 2½ ft. It should be ideal for the smaller factory and prove a useful addition in a large one.

Special consideration has been given to the period of moulding and the necessary retention of temperature and pressure during the moulding cycle, and not too high speed production resulting in possible loss of efficiency.

The machine comprises a base casting supporting a pillar casting, on top of which is mounted the hopper for easy replenishment of the raw material. Contained in the base casting is the electric motor and pump, also the pressure-relief valves and water-drainage tank. Reference to the engineering literature published by the company shows that projecting from the pillar casting at the front and back of the machine are the adjustable tables with the tool slides mounted thereon. These tables are adjusted up and down vertically by means of the handwheel rotating about the fixed adjusting screw. Also projecting from one side of the pillar is a bracket on which can be placed a suitable hot plate to be used for warming the mould, a switch plug being conveniently placed beneath this bracket.

Granulated or powdered plastics material is placed in the hopper which automatically feeds down to the heated cylinder each time the ram is raised above the top. The molten plastic is ejected under pressure from the cylinder through the two nozzles into the moulds. The mould is accommodated on the tool slide, but should be heat insulated by a piece of asbestos sheet or similar material.



Visual indication is arranged to show the working conditions of the apparatus. The heater lamps indicate the heating conditions when controlled by the thermometer.

Water nozzles are provided for the water supply for cooling the mould and the waste water conducted away by hose through apertures in the tray to the drainage tank.

Maintenance is very simple and all that is necessary is to lubricate screw threads and sliding surfaces occasionally. Periodical maintenance will be necessary for the "Electraulic" equipment.

The machine is marketed by Stedall Machine Tool Co., of St. John Street, Clerkenwell, London, E.C.1.

PHTHALATE PLASTICIZERS.—British Industrial Solvents, Ltd., announce that as a result of decreased demand by the Government the following materials are now more freely available and, apart from direct exports, will not henceforward require licences:—Dimethyl phthalate, diamyl phtha-

late, diethyl phthalate, dihexyl phthalate, dibutyl phthalate, dioctyl phthalate.

In conjunction with the recent release of diacetin triacetin and tricresyl phosphate, almost all important cellulose acetate, nitrocellulose and polyvinyl chloride, etc., plasticizers are now free from direct Ministry of Supply licensing. During the past few years productive capacity has been increased many times, and provided raw material releases continue as at present, there will be no difficulty in meeting demands very much larger than pre-war.

CRYSTALATE LTD.—At a meeting of the directors of the above company it was resolved to recommend a dividend of 6 per cent. less tax on the Ordinary stock of the company. Net profit for the year £13,059, against £11,385. Provision for taxation £11,600, against £33,300 last year. Carry forward £10,894, against £8,222.

REED BROTHERS (ENGINEERING), LTD., operating as engineers and machinery traders, has just been formed, three of the four directors having recently resigned their long-standing appointments with Messrs. George Cohen Sons and Co., Ltd. They are Mr. H. E. Reed, A.I.R.I.(Eng.), for the past seven years manager of the Hydraulic, Plastics and Rubber Machinery Department; Mr. O. O. Fogg, formerly Assistant Manager of the above; Mr. G. W. Reed, F.V.I., for 27 years Chief Valuer of George Cohen Sons and Co., Ltd. Whilst it is proposed to trade in modern reconditioned plant and machinery of all types, the company will specialize in hydraulic, plastics, rubber, process and chemical plant. In addition, the conversion and manufacture of special items of plant to customers' individual requirements will be undertaken, and plant maintained, dismantled, installed and erected.

MYCALEX CO., LTD., Cirencester, announce that their three directors who were in H.M. Forces have now safely returned. Mr. M. W. Ingram, who was a major in the Grenadier Guards, is taking over the post of managing director of the company.

I.C.I., LTD.—Mr. Gordon Long has been appointed Press officer to Imperial Chemical Industries. He began his career on the advertising staff of "The Bulletin," Glasgow, and in 1936 joined I.C.I. at the invitation of Mr. Sidney Rogerson. Mr. Long saw service in N. Africa, and, later, joined the Psychological Warfare Branch. In 1943 he ran a daily newspaper in Libya for the Italian population.

MILLBANK PLASTICS, LTD., inform us that in future all communications should be addressed to Portland House, 164, Cavendish Street, London, W.1.

FRANCIS SHAW AND CO., LTD.—We have pleasure in announcing that Major Francis B. Shaw has now been released from the Army and has rejoined the company.

U.K. PLASTICS LTD.—Mr. F. Pim Roche, director of U.K. Plastics Ltd., sends us the sad news that Mr. W. J. Pollock, the chairman of the company, died on November 4. To many of our readers he was also known for his long association with the company under its original name, Celluloid Printers Ltd., and for his enthusiastic interest in plastics and printing thereon, which remained unabated up to within a few days of his death.

DR. C. G. LEMON, who for the past four years has been director of technical development at Messrs. Tenaplas Ltd., plastic extruders, of Upper Basildon, Berks, is re-establishing his pre-war practice as technical consultant. His own laboratories (A.I.D. approved) will continue testing as before to M.A.P. and other specifications as well as conducting research on industrial problems. Address for mail: "High View," Streatley, Berks.

UNIVERSAL METAL PRODUCTS LTD. announce that Sir Harold Webbe, C.B.E., M.P., has joined the board of the company.

MR. O. P. MARTI has resigned his position as sales manager of Catalin, Ltd., and has joined the board of Plastic Specialities, Ltd., 25, Victoria Street (South Block), London, S.W.1. This company, he tells us, would be pleased to hear from any firm in the plastic trade interested in export or in London representation.

MAJOR STANLEY M. MOHR, O.B.E., M.C., M.I.E.E., managing director of the Micanite and Insulators Co., Ltd., has been elected president of the Institute of the Plastics Industry for the session 1945-1946. Major Mohr was chairman of the British Plastics Federation for five successive years from 1939 until 1944, and under his energetic guidance at a most important time in its history the Federation gathered strength and made encouraging progress.

PATENT REVIEW

B.P. 571,657. Application date: 1.9.42. Accepted: 4.9.45.

Improvements in and relating to the Manufacture of Alginate Threads. H. J. Hegan. To: Courtaulds, Ltd.

Method of producing threads from alginic acid by projecting an aqueous solution of alkali alginate into a bath containing a salt of a metal forming an insoluble alginate, e.g., calcium. The thread is then advanced mechanically and treated with a solution of this salt until the conversion into the metallic alginate is completed.

B.P. 571660. Application date, 6.4.43. Convention date: U.S.A. 11.4.42. Accepted: 4.9.45.

Improvements in and relating to Resinous Condensation Products. British Thomson-Houston Co., Ltd.

B.P. 571,662. Application date: 11.5.43. Convention date: U.S.A. 29.12.42. Accepted: 4.9.45.

Stabilization of Polyvinyl Acetal. Wingfoot Corporation, Akron.

The invention covers a method of heat stabilizing polyvinyl acetal resins by incorporating a small amount of urea, thiourea or other forms of urea acting as stabilizers. The invention is also applicable to polyvinyl butyral resins.

B.P. 571,695. Application date: 26.6.43. Accepted: 5.9.45.

Improvements relating to Thermoplastic Polymeric Materials. H. Dreyfus.

Relates in particular to thermoplastic water insoluble materials for moulding and comprises a polymer of a substance containing a $CH_2 = C<$ group. Examples stated are polymethyl, methacrylate or other polymers, the basis of which is acrylic acid or a derivative of this acid combined with a plasticizer. Polymerization is achieved in solution in a homogeneous mixture of water with a more volatile liquid acting as a solvent for the polymer. This mixture may contain a plasticizer for the polymer and the special purpose of the invention is to produce a mixture of polymer and plasticizer which is easy to grind.

B.P. 571,701. Application date: 24.8.43. Convention Date: U.S.A. 2.9.42. Accepted: 5.9.45.

Improvements in or relating to the Manufacture of Oil- and Grease-resistant Sheets and Films. British Cellophane, Ltd.

Materials covered by the invention may be used for the packaging of edible oils and fats, oils and other greasy foodstuffs. A specific object of the invention is to provide heat-scalable sheets which are highly resistant to penetration by oil and grease and are also impervious to water vapours. The basis of these sheets consists of a non-fibrous water sensitive organic sheet or film which is coated, at least on one side, with a mixture comprising a film-forming agent (cellulose derivative) and an oil insoluble plasticizer.

B.P. 571,708. Application date: 17.9.43. Convention date: U.S.A. 17.9.42. Accepted: 5.9.45.

Improvements in or relating to the Production of Linear Polyamides. E. I. Du Pont de Nemours and Co., Delaware.

Process for the production of linear polyamides by heating a linear polyamide-forming composition consisting of at least one dicarboxylic acid having a mercapto group separated by at least three atoms from its amide-forming groups and continuing heating until the formation of fibres is achieved. The products obtained may be used for fibres, bristles, films, foils, ribbons, etc., and also for moulding compositions and impregnating purposes.

B.P. 571,725. Application date: 9.4.43. Convention date: U.S.A. 26.2.42. Accepted: 6.9.45.

Improved Method of Preparing Silicones and Products thereof. J. F. Hyde. To: Corning Glass Works, Corning.

This invention refers particularly to the lower alkyl silicones and discloses a process for producing polymeric dialkyl silicones by heating a composition obtained by condensation of a mixture of organo-silicoles to a temperature high enough to cause vaporization of the composition. The fibrous products are then collected afterwards.

B.P. 571,727. Application date: 3.5.43. Convention date: U.S.A. 22.4.42. Accepted: 6.9.45.

Improvements in or relating to Polyvinyl Acetal Compositions. Imperial Chemical Industries, Ltd.

Refers particularly to the insolubilization of polyvinyl acetal resins and also to the manufacture of plywood.

This linen *doesn't go to the laundry*

The cloth of various kinds which comes into our factory will never see a laundry. We treat it with synthetic resin and sheets of it are bonded together under heat and pressure to make the Paxolin from which quiet, smooth-running gear wheels are made. Paxolin, of course, is made in different grades from a variety of treated materials ranging from paper to woven asbestos, and because it is strong and easily machined has a great number of electrical and mechanical applications. We're always ready to set the wheels moving in response to an enquiry as to the suitability of Paxolin for any particular purpose.

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An improved polyvinyl acetal composition is obtained by incorporating .5 to 50 per cent. of monocyclic urea derivatives having on each cyclic urea nitrogen a methylol group, etherified with an alcohol boiling not higher than 210 degrees C. The process may be further improved by adding conventional catalysts.

A further purpose of the invention is the manufacture of plywood whereby a polyvinyl acetal composition, as mentioned above, is used as binder.

B.P. 571,736. Application date: 4.8.43. Convention date: U.S.A. 15.9.42. Accepted: 6.9.45.

Dehydrogenation of Butenes to Butadiene. F. M. Pyzel. To: Shell Development Co., Delaware.

The subject of this invention is thermal non-catalytic dehydrogenation of hydrocarbons and particularly the manufacture of butadiene from butylene.

B.P. 571,750. Application date: 2.9.43. Accepted: 7.9.45.

Nitriles and Polymers thereof. Communicated by: Wingfoot Corporation, Akron. Application by: W. W. Triggs.

Relates to unsaturated nitriles and polymers containing such nitriles and specifically to nitriles containing chlorine and are suitable to be polymerized; also to methods of preparation of such nitriles and polymers.

B.P. 571,784. Application date: 25.5.43. Convention date: U.S.A. 27.4.42. Accepted: 10.9.45.

Improvements in Plasticizing of Vulcanized Rubber. W. W. Evans. To: Boston Woven Hose and Rubber Co., Boston.

Discloses a treatment of vulcanized rubber whereby it can be converted into a form suitable for the manufacture of new rubber articles, and particularly to a process for plasticizing vulcanized rubber scrap by mechanically working the material under oxidizing conditions with an admixture of fatty acids and a mercaptan or thiophenol. A particular purpose of this invention is the reclaiming of rubber tyres, and it is stated that the plasticized scrap so obtained can immediately be compounded again and used for new vulcanized products.

B.P. 571,786. Application date: 9.9.43. Accepted: 10.9.45.

Improvements relating to Mouldable Compositions and to Methods of Making the Same. F. Frank.

A mouldable composition is made from resin-containing sawdust by heating this in the presence of water with a hydroxide of an alkaline earth metal and evaporating the water subsequently. A small amount of a thermoplastic or thermosetting materal may also be added. Low moulding pressures are claimed for the new material.

PLASTIC HATS

The country has certainly taken to polyvinyl chloride in most of its forms. Tablecloths, shoes, head-wraps, belts, tobacco-pouches and so on have appeared on the market and are being thoroughly appreciated because of their washability and the profusion of possible colour schemes. On the other hand, a scientific pronouncement on the relative merits of leather and P.V.C. is still lacking but necessary.

Hats made from the sheet or from strips or extruded P.V.C. are also an obvious production and the accompanying photograph, while not, we submit, a good example of the photographer's art, shows an excellent design of the plaited type by the well-known Mr. Hugh Beresford.

Certainly P.V.C. hats will never look bedraggled in the rain and can even be kept bright with polish and a boot-brush!

Table A.—Physical Properties of Laminates ... Various Grades Glass Cloth ...

Allyl Esters

By N. H. CHAMBERLAIN, B.Sc.

(Technical Products, Ltd.)

THE chemical reactivity of the allyl group has long made allyl esters objects of study as starting materials in the production of resinous substances, and, as a result, allyl esters were among the first compounds to be used in the commercial manufacture of thermo-setting, low-pressure laminating resins. Allyl esters of a number of dicarboxylic acids have been found to polymerize readily to insoluble, infusible solids, the final product varying somewhat according to the acids chosen. Allyl esters of more complicated structures have proved their value in the commercial production of clear castings and laminates.

In general, the allyl esters are well adapted to the preparation of laminates from fabrics of various kinds, including cotton, "Fortisan" and glass, paper and wood veneer. The following outline of the polymerization characteristics of a typical allyl ester and the properties of laminates prepared using such resin as an impregnating and bonding material will illustrate the results obtainable.

Polymerization of Allyl Esters

The pure allyl esters of dibasic acids are colourless liquids of low viscosities comparable to kerosenes and light spray oils and with specific gravity of 1.1.-1.2. They are soluble in alcohol, acetone, ethyl acetate, and benzine, but are insoluble in water.

The monomers, when heated with an organic peroxide such as benzoyl peroxide, undergo a true polymerization; that is, molecular weight increases through linking together of molecules of monomer without formation of water or other by-products. There is no loss in weight, although polymerization from monomer to a hard solid results in from 10 to 13 per cent. volume shrinkage. It is believed that polymerization proceeds by initial formation of chains to which each molecule is linked through only one side-chain, with subsequent reaction of the remaining sidechain, double bonds causing cross-linking.

The polymerizing material passes through various physical stages. At first the viscosity increases as increasing proportions of relatively low polymers form but remain in solution in the monomer present. These clear, viscous solutions of polymer in monomer, which may contain 15 to 30 per cent. of polymers, are termed "partial polymers" or "pre-polymers," since they are often deliberately made as an initial step in making solid polymer. Polymerization next reaches the point where such high proportions of polymer or polymers of such high molecular weight are present that the polymerized material is no longer soluble in the monomer remaining, and a gel forms. In general, the gels are difficult to handle, polymerization having proceeded to the point where a considerable proportion of the material is insoluble, although fusible. The final stage of polymerization is a solid, which, for the most practical purposes, is no longer thermoplastic and which is unaffected by most organic solvents.

Control of Polymerization

With benzoyl peroxide catalyst, temperatures as low as 65 degrees C. are sufficient to start polymerization, which may be carried through to completion at that temperature. This level-temperature cure requires an extended period, however, and a more suitable practice is to start the cure at temperatures of 65 to 75 degrees C., with a gradual increase to an end temperature of 125 to 150 degrees C. The increasing temperature cycle

Table A.—Physical Properties of Laminates. Various Grades Glass Cloth and a Typical Allyl Resin.

Laminating pressure, 1 lb. per sq. in.

Type of glass cloth	ECC-127	ECC-148	OC-64	OC-64	OC-64
Ply assembly	Crossed	Crossed	Crossed	Crossed	Parallel
Specific gravity of laminate	1.75	1.68	1.56	1.51	1.53
Weight % resin content	—	39	48	53	53
Compression test :—					
Ultimate strength, psi	28,800	—	29,800	48,080	61,200
Tensile test :—					
Ultimate strength, psi	45,900	31,400	34,600	33,400	90,800
Modulus, psi × 10^6	2.5	2.1	1.8	1.8	3.7
Dynstat impact strength, kg./cm.^{2}	280	290	290	160	390
Barcol hardness	66	65	59	65	64
Rockwell hardness, M scale	119	—	—	—	—

greatly reduces the time required for complete polymerization. High initial temperatures are not advisable because of a too-rapid initial reaction.

Polymerization liberates heat; this heat of reaction has to be removed from the polymerizing mass, or the temperature will rise uncontrollably, resulting in very rapid polymerization to produce soft and sticky polymers of relatively low molecular weight rather than the desirable solid high-molecular weight polymers. The danger of rapid polymerization occurring is much greater with a large proportion of monomer present. At later stages there are fewer groups available for reaction, and the danger of uncontrolled polymerization disappears, therefore higher temperatures may be employed with advantage to hasten the final cure. The limiting factor in the speed of cure in any polymerization is the ability of removing the heat of reaction; this will depend on such physical factors as the thickness of the castings, the nature of the filler, heat conductivity of the platens, etc. Thin laminates can, of course, be cured more rapidly than thick ones.

Satisfactory laminates can be made by polymerization of the monomer, but there are a number of advantages in making prepolymer separately and using the more viscous liquid as a starting material in laminating or casting. The advantages of prepolymer over monomer are that the former is less sensitive to temperature (especially in the early stages of curing), it adheres better to non-horizontal surfaces, shrinks less during cure, and requires much less time at any given temperature to effect a complete cure. Prepolymer containing catalyst will undergo continuous slow polymerization

Table B.—Physical Properties of Laminates. Various Other Laminates with a Typical Allyl Resin.

Laminating conditions, 1 lb. per sq. in. in 4-hour cycle.

Type of material	Muslin No. 10	Army duck	"Fortisan"	Mitscherlich paper*	
Ply assembly	Crossed	Crossed	Crossed parallel	Crossed	Crossed
Specific gravity of laminate	1.30	1.38	1.29–1.41	1.34–1.40	1.32
Weight % resin content	63	—	59–61	57–59	30.5
Compression strength, psi	23,500–25,300	26,600–31,100	19,100–26,400	27,800–29,800	17,700
Tensile strength, psi	7,500–8,100	8,700	14,300–19,600	31,300–43,800	27,100
Modulus, psi × 10^6	0.79–0.90	0.76–0.78	1.2–1.4	2.3–2.4	2.4
Dynstat impact strength, kg./cm.^{2}	85–90	100–130	100–110	200–215	50
Barcol hardness	45–49	47–51	42–52	48–52	58
Rockwell hardness	—	102	101–103	109	—
Heat distortion point °C. (ASTM D648-41T test)	—	110	160–175	—	—

* 8-hour cycle.

even when cold, and will gel within a few weeks after preparation at normal room temperature.

Preparation of Laminates

Five per cent. benzoyl peroxide is dissolved in the monomer and the monomer is partially polymerized by heating under reduced pressure at 65 degrees C. This reaction is exothermic and must be cooled when the desired stage of polymerization has been reached, otherwise an unworkable gel will be formed. This reaction is not difficult to control when suitable equipment is employed.

The partially polymerized liquid is placed in suitable pans or impregnating tanks designed for the specific application at hand and the fabric or other laminating material is immersed therein for saturating with polymer. In some cases, rolls may be employed to facilitate impregnation. If a smooth, glassy finish is desired on a panel, for example, the several layers of saturated fabric should be assembled between polished metal platens or glass plates while immersed, clamping the assembly together lightly and removing same from the tank or pan for draining before applying heat for curing. Curing may be carried out with various types of ovens, platens, or with high-frequency or infra-red heating.

The rate of curing is dependent upon the size and nature of the article being fabricated. Generally, cures may be effected in from one to two hours, and on many types of assemblies a shorter cure period may be developed by experiment.

ADHESIVES BASED ON SHELLAC

(Continued from page 592)

based on shellac for every bonding job.

The work described in this article has been carried out by the author in the research laboratories of Messrs. Metropolitan-Vickers Electrical Co., Ltd., Manchester, under the scheme of co-operative research on the uses of lac in the electrical industry sponsored by the Indian Lac Cess Committee. The author wishes to express his grateful thanks to Mr. A. R. Dunton, of the Materials and Process Section, Research Department, for his continued interest during the development work and for the help given in preparing this paper for publication. Thanks are also due to Sir A. P. M. Fleming, Director of Research and Education, Metropolitan-Vickers Electrical Co., Ltd., and to Dr. B. S. Gidvani, Acting Director, London Shellac Research Bureau, for permission to publish this article.

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New Furniture Export Trade for Britain

A new type of furniture for export to Eastern and tropical countries, which is unaffected by climatic conditions or attack by insects, has been developed by the Tube Investments Group of engineering industries at their Pel Works at Oldbury, near Birmingham. Some thousands of the chairs and tables have been produced and are already in use with the S.E.A.C. Forces.

The framework of the chairs and tables are prefabricated from steel tubes, while the seats and table-tops are made from heat- and insect-resistant plastics, which can be provided in a range of colours to meet overseas customers' tastes. Following research, the seats have been so moulded as to give comfort equivalent to that of a sprung leather or canvas chair.

The furniture can be stacked, thus requiring little shipping space for export. Plant is being made available at Oldbury for large-scale production.

Planned Mould Maintenance Service Aids Economical Production

Section XVII

By W. M. HALLIDAY

In this section continuing the interesting study of inserts, their feeding and retaining mechanisms and associated design, operating and maintenance problems; particular attention is now given to those injection mould constructions necessitating the location of the insert-component at a point in a plane not at right angles to the mould parting-line.

Such inclined insert-locations require specially careful consideration, and often demand some adaptation of the design and mechanism of the pre-loaded magazine plate used for delivering or holding the inserts into their correct situation. In some cases their application incurs modification to the mould design.

Only a few very practicable types of feeding mechanisms for such uses can here be considered, before passing on to the study of gravity or purely automatic feeding of inserts.

It will be specially observed from the examples here given, that their incorporation usually involves some added complication of mould construction and that of the auxiliary feeding device.

This in its turn demands more stringent maintenance service in the shape of more frequent inspections to detect developing wear and other faults.

IN the immediately preceding sections devoted to the study of pre-formed inserts, and the problems associated with their accurate and rapid feeding or location, together with the various forms of mechanical devices which can be used to facilitate such functions, it will doubtless have been particularly noted that almost all the illustrated examples of typical mould lay-outs have possessed one common characteristic, i.e., that the plane in which the insert component had to be located has always been at right angles to the parting-line of the mould.

This feature is one which it is urged should be adhered to as much as possible, because of the simplification of mould construction it generally affords. It permits all the seating holes, etc., needed to retain the insert component in position within the mould cavity to be machined at right angles to the parting-line surfaces of the mould blocks. Thus, all such machining operations and settings of the mould blocks for those operations become much simplified, whereas when the seatings have to be inclined either greater or smaller angles than 90 degrees setting-up for machining becomes more involved.

Furthermore, all auxiliary devices designed to ensure speedier or more accurate delivery and retention of insert parts (some of which have already been described and illustrated in some detail in previous sections) can usually be fashioned upon simpler lines of construction and operation when the insert has to reside exactly at right angles to the mould parting-line than in those cases where it is inclined outside that limit.

This factor alone, it will be appreciated, is one of considerable assistance both to the mould designer and maintenance toolmaker, in that it permits the number of working parts in both mould and pre-loader mechanism to be maintained at a minimum. Similarly, their mode of operation can usually follow straightforward lines, thereby leading to less strain and wear. Mould and auxiliary feeding device components can also be made amply strong enough to withstand heavy load and prolonged action without incurring too great a demand upon available space. This indeed is often a very limiting factor since the amount of mould block opening will largely determine the size of pre-loading device which can be used.

On the other hand, cases do arise very frequently where the designer has no alternative but to employ a mould construction wherein one or more inserts have to be located at an unusual angle of inclination to the parting-line surface. This may be greater or smaller than 90 degrees, of course, but most often where the angle is a very acute one in respect of the parting-line the difficulties are so great as to render use of an insert inadvisable, and some other means has to be found for accomplishing the user's requirements. Small angles of inclination can be very effectively dealt with, however, and large numbers of moulded articles are made at the present time embodying inserts located in this wise.

But in mould designs where such locations are stipulated, very often there is a number of manufacturing, machining, or design difficulties whose solution often results in an unavoidable complication of the mould structure, or in that of the preloading mechanical arrangements devised to meet the job. Especially are such complications liable where the mould is of the multi-impression type requiring a large number of insert components, each inclined out of normal right angle.

Before commencing the discussion of the design and constructional features of typical pre-loading devices applicable for angular disposition of insert parts, it will be advisable briefly to enumerate some of the chief difficulties confronting the designer wishing to employ inserts in such situations. These will doubtless serve as a useful guide both in helping to determine design forms which the mould and feeding auxiliary should preferably follow, and also indicate some of the main operating troubles it is advisable to avoid. They are, then, as follow:—

(a) Where the insert member has to be situated at a fairly large angle of inclination to the parting-line it will be essential to provide some reliable positive means for holding the insert in place before the blocks are brought to their closed position in readiness for injection. Otherwise the act of moving the blocks during normal closure movements will tend to displace the inserts, since the angle of their inclination will be such as to assist such movement. Where the inserts have to fit straight into a seating hole machined at right angles to the parting-line there will obviously be much less likelihood of accidental displacement.

(b) Not only will such positive retaining facilities be required in respect of the mould block housing the inserts, but they will be likewise necessary and for the same reasons, in the auxiliary pre-loading magazine plates or devices employed for feeding the inserts into position. This, indeed, very often presents a very knotty problem for the designer, especially where the inserts are of large size or heavy in weight, when the retention grip upon them must be considerable so as to hold them in their proper position throughout the handling of the feeding magazine prior to its inclusion into the mould assembly.

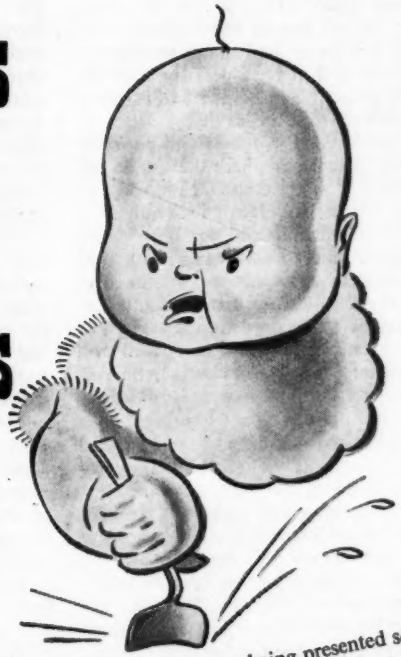
(c) By reason of inclination of the insert relative to the parting-line the design and constructional details of both mould and auxiliary magazine feeder will tend to be increased in both number and degree of complexity. This will arise usually from the need to utilize the straight-line movement of the mould halves needed for their opening and closing, to impart the required angular motion to the insert holders of the feeder device.

(d) This increase in number of mould working parts, and more intricate functions they are called upon to fulfil inevitably incurs greater possibilities of wear, failure, damage, seizures, inaccuracy, and so on, all of which entail closer and more skilled maintenance service to secure their avoidance or early correction when discovered.

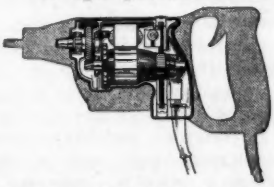
(e) Yet another very important matter relates to the provisions which have to be made in both mould and the preloader magazine plate or similar feeder device, whereby extraction of the complete moulded article can be accomplished readily and safely without injury to mould members, or faulting of the

because of the simplification of mould loading device which can be used.

GREAT OAKS FROM LITTLE WHATNAMES GROW



IT IS RECORDED of our Managing Director that on being presented some years ago with a silver spoon and pusher, he remarked: "Damned clumsy contraption"—and continued to shove potato and gravy into his mouth with his fingers. Who could then foresee that this cuddly bundle of babyhood was already showing the traits that in later years were to revolutionise the design of portable tools? Not his parents, nor his tutor, who rebuked—often with a clothes brush—the child's early efforts to avoid what he regarded as unnecessary labour. Yet here we show you by diagram which even the meanest intellect can follow (*Come, come, apply your mind to it!*) how the shape, size, and weight of light portable tools were changed overnight by the appearance of the first Desoutter Tool. The bud had blossomed. The twig had grown from sapling to sturdy tree. The child was father to the man. The early fumblings of tiny fingers . . . aw, drat the brat!



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C.B.C. 152

wise the act of moving the blocks during to mould members, or faulting of the

moulded part. This is not a simple matter, largely due to the inclined situation of the insert, and many undesirable objections will arise, especially after the moulding has been formed and is ready for removal from the cavity.

Obviously, such troubles will be intensified in those cases where the mould has a number of insert components, some or all of which are located at different degrees of inclination to the mould parting-line and to each other. In these circumstances especial care will have to be observed to ensure that no fouling or trapping of the moulded-in insert piece occurs when the blocks are opened and the auxiliary feeding device is removed. Provisions of an automatic and purely mechanical nature for ensuring such clearances should be incorporated wherever possible. Where manual operation of some mould part, etc., is relied upon to secure such clearance, trouble will sooner or later arise, due to momentary forgetfulness on the part of the operator. Thus, for these reasons alone, the construction of the mould itself may have to be drastically modified in some respect to guarantee feeding and clearing of inserts when the feeding device has to be removed in between shots.

(f) Usually the need for inclined location of inserts beyond the usual right-angled one raises a number of machining problems, some of which may not easily be overcome. The provision of such seatings may involve unusually difficult setting-up of the mould blocks or arrangement of the pre-loading device.

All these, then, are some of the chief considerations which the mould designer and toolmaker should bear in mind before deciding upon the use of inserts inclined to the parting-line. The best way to avoid or solve them will be to give the closest study to all aspects involved in their application whilst the mould design is still in its elementary stages and certainly before any actual manufacture has been commenced. It should always be borne in mind that a good deal of flexibility as regards design and construction is usually permitted in the early stages of design, and it may well be that if a special type of magazine preloader has to be employed, many slight adaptations to the mould construction will be more easily possible than if their consideration were to be deferred until later on when the main forms of the mould design had been established and perhaps reproduced on the machine.

This is not to suggest or imply that the use of inclined insert locations on a mould are not feasible or even practicable. Indeed, this would be far from the truth, as will be evidenced amply by the several illustrations in the following pages of examples of one or two typical mould layouts designed for the use of pre-loaded magazine plates.

Many injection mouldings are being regularly produced of this type quite successfully and most economically, and given due consideration sufficiently early in mould design development many troubles can be effectively eliminated.

The objections have been stressed here, however, in order to indicate how important it is for the methods of insert feeding and location, etc., to be carefully thought out before the main features of the mould construction have taken concrete shape in the manufacturing stages of its manufacture.

It is now proposed to devote a little space to the consideration of a few mechanisms which have been applied as effective solutions of the foregoing troubles in connection with injection moulds having to embrace inserts located off the right angle to the parting-line surface.

These examples have been chosen on account of their mechanical soundness and simplicity of design form, coupled with substantial enduring and working capacities, and thus will doubtless indicate to the designer and the maintenance toolmaker not only ways in which those difficulties may be overcome in other mould applications, but also will show numerous ways in which the various operating snags can best be guarded

against, and the working life of the mould and all its auxiliaries improved, maintained and rendered free from those irritating troubles so harmful to economical production.

Method of Presentation

In presenting these examples the author will follow his usual practice, viz., that of embracing upon one drawing a number of unsatisfactory and also many of those generally preferred forms of design and construction.

Special attention will, of course, be given to those features best calculated to ensure smooth, trouble-free operation of the moulds or their auxiliary devices, so entailing the least amount of maintenance service and attention.

The moulded components selected for these illustrations and consideration are of a simple type, yet characteristic of numerous articles, so that it will be appreciated that some of the commonest kinds of design, construction, operation and maintenance problems are covered. In this way the designer and mould engineer will not only derive some understanding of the mechanical form and devices applicable, but also will realize those capable of affording the least troublesome service.

A Modified Type of Pre-loading Plate for Inclined Locations

As was explained in the previous section, use of a plate or magazine block capable of being loaded apart and away from the mould proper with the required number of insert components, and then suitably interposed between the two mould halves prior to injection, being held there throughout the moulding cycle, is an arrangement which certainly presents very substantial advantages and economies to both designer and maintenance toolmaker.

Such a pre-loaded plate may either be devoid of any cavity formation or may contain portions of same as convenient. Its main purpose is to permit the insert pieces to be assembled into their correct position without each unit being admitted to the mould separately, thus greatly reducing loading time in between shots. The inserts are thus correctly located and faithfully retained until the moulding

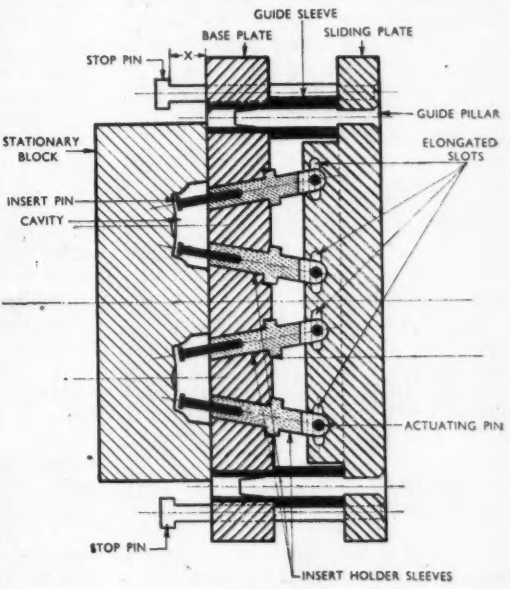

Fig. 1.

cycle has been completed. Obviously, these requirements are especially important in the case of a mould having inserts inclined at unusual angles other than 90 degrees to the parting line.

In Fig. 1 is shown an interesting kind of construction which comprises an adaptation effected to the pre-loaded plate of the kind already described, which arrangement is designed to permit locating and holding a number of inserts within a mould cavity area throughout the moulding cycle. This modified form

of pre-loading plate is of very simple construction, and has a smooth, sure mode of operation amongst other useful features. Turning now to the illustration this shows a sectioned view only of the partially assembled mould. For the sake of clearness the movable mould block has been omitted altogether. It should be explained that in this mould no cavity formation, or core locations are contained in the movable block, but before the introduction of the special pre-loading plate about to be described, seatings were provided in the parting-line face of the moving block in which the insert studs had to be placed prior to each moulding shot.

The mould is a four-impression tool, whilst the moulded article consists of a small cylindrical disc having a domed head, and has two plain shanked-headed studs moulded in place as shown. Each stud is inclined at 100 degrees to the parting line instead of at the usual 90 degrees, and it will be seen the angle of inclination is in opposite directions with each pair of insert studs.

Before the application of the special pre-loader plate, the task of efficiently and accurately feeding and locating the studs in this manner occasioned a good deal of trouble, since it proved extremely difficult and unreliable when seating them directly into the parting-line face of the movable block. These difficulties largely centred around the following points.

First, it was found that an operator experienced much trouble and irritation when having to apply the inserts into their respective seating holes, since the closeness of fit of the studs therein had to be maintained within very fine limits of deviation. The reason for this was that if the studs were allowed to be an easy slip fit within their seating holes, those inclined in a downward direction easily became displaced or even fell out of position when the mould block was moved during its closure. In point of fact this latter snag gave rise to one or two nasty trappings of the mould members, as it was found that an insert sometimes became completely dislodged from its seating, and could not fall clear of the closing mould block, as a result of which it became very forcibly jammed into the cavity area causing severe damage to the surface of the cavity, extreme straining of other mould parts, and generally entailing the maintenance toolmaker in a considerable degree of corrective work.

Secondly, numerous objectionable features arose when the finished moulded article had to be ejected. This was withdrawn from the main cavity in the stationary block when the moving one was withdrawn, but it could not be stripped from this latter member so easily because of the oppositely inclined inserts, fitted with a projecting portion within the moving block. To accomplish this task successfully entailed splitting the movable block into sections, and the result was a number of additional flash lines being formed across the top face of the moulding, as well as a slowing down of the operation due to the need for first withdrawing the section of mould block immediately surrounding the inserts.

Thirdly, it was found that after only a very short period of operation the seating holes in the movable block tended to wear bell-mouthed, resulting in the formation of flash, and also the far more serious loss of angle in the case of insert location. It necessitated repeated corrections to the movable block and its insert seatings to restore original true shape of holes.

These operating objections were overcome by the use of the pre-loader of the kind shown, and by making the movable block serve simply as a plain clamping piece between the pre-loader and machine platen.

The device consists of a stiff sectioned base plate sufficiently large as to allow for an ample amount of overhang at top and bottom of the stationary block as indicated in Fig. 1.

Connected to this base plate is another sliding plate of exactly the same overall dimensions. Four ample proportioned guide pillars are securely riveted to this sliding member in the manner illustrated, and on their large diametered portion made to slide within the bore of the

hardened guide sleeves, which in turn are secured firmly into the base plate. A good degree of lead is provided to these guide pillars, and they should be so arranged as to lie out of the orbit of the insert holding members of the device.

The amount of sliding movement of the sliding plate relative to the base is controlled by the four headed studs or stop pins, which are permanently secured to the sliding plate and pass through clearance holes drilled through the base plate. The exact function performed by these stop pins will be explained more fully later when the operation of the device is dealt with.

The insert retaining units are all contained within the base plate, which latter member is machined with a number of holes inclined at suitable angles to coincide with the inclination required in respect of the insert pieces, and of course correctly disposed so as to bring the inserts into the proper relationship with each cavity formation.

These holding units consist of hardened and ground cylindrical members, drilled up one end concentrically for a certain depth, into which hole the insert was smartly fitted. The fit was such as required a moderate finger pressure to press them home into position. This was necessary in order to ensure proper retention of the inclined pins. Each holding pin was then made a sliding fit within the hole machined through the base plate. An enlarged shoulder portion was provided on the exterior of each holder as indicated, this serving as the stop against any undue endwise movement, and also to act as a positive stop whereby each holder member could be correctly situated in the base plate.

The right-hand end portion of each holder was then slotted for a suitable depth and cross drilled to take a pin. This slotted portion was made an easy fit over the thin projecting strip provided integrally with the front face of the sliding plate. A number of elongated slots were machined in this strip portion through which the short actuating pins could be passed. In this manner the ends of each insert holder and the sliding plate of the device were connected.

Operation of the Pre-loading Device

The advantages and drawbacks of this type of mechanism can perhaps best be appreciated from the description of its method of working and the functions performed by each member.

The loader is first placed on a separate table removed from the mould, of course, with the left-hand face of the base uppermost. The feeder then inserts the required quantity of insert studs into the holes in the holders, pushing them down until bottoming ends of holes in each case. It will thus be noted that the depth of hole in each holder is an important dimension and variations to any appreciable extent may cause troubles. Whilst this loading operation is being performed the base and sliding plates will be in the same position as shown.

When loaded the device is then placed into position between the mould blocks. Location on the stationary block is secured by passing the base plate over the four ordinary dowels contained in the former member, but again for reasons of clearness this method of fixture has not been shown in Fig. 1. In this way the entire device is correctly positioned so as to bring each set of insert studs into proper relationship with their cavity.

The next step is to close the mould, performed by bringing the moving block up against the right-hand endface of the sliding plate. Clamping pressure will be taken largely by the ends of the guide sleeves attached to the base plate. Coincident with this it will be seen that the shoulder of each insert holder unit is also made to bear against the recess formed in right-hand side of base. When the holders are thus positioned their extreme left-hand endfaces should lie perfectly in line with the face of base.

With the mould thus closed and all members of the pre-loader occupying the positions shown, an injection shot can be made. After this has been performed, ejection of the moulded article is secured in the following manner.

The movable block is withdrawn to its extreme open position, and the pre-loading device then removed from the stationary block. This operation causes the mouldings to leave the cavity portions and come away with the loader. The whole device is then lightly dropped on to a flat table top, base plate downwards, so that the heads of the four stop-pins first contact the table. This will cause the sliding plate to be pushed outwards from the base plate, and the holder members will also be withdrawn from the now moulded-in insert studs.

Because of the method of connection between the insert holders and the projecting strip on sliding plate the former are able to move along the line of their respective inclination whilst the sliding plate moves along a line at right angles to the parting-line face.

When the insert holders have thus been retracted a sufficient distance to allow them to clear the ends of the moulded-in insert studs embedded in the moulding, the latter may be removed readily. To obtain this endwise clearance it will be necessary for the sliding plate to move outwards equal to distance X, the required amount being denoted when the head portions of the stop pins affixed to the sliding plate bear down against the left-hand side of the base plate.

It will also be appreciated that the diameter of the insert holder sleeves should be sufficiently large so as to permit the extraction of the finished ejected moulding when sleeves are withdrawn. The diameter of these members will to some extent be determined by the length of projection of the insert studs into the base plate, and also by their angle of inclination.

For the reloading operation, the device is simply reversed so that the sliding plate is resting upon the table, and then the base plate is depressed until returned to the position indicated in the drawing. This it will be seen occurs when the guide sleeves make contact with the sliding plate. Inserts are then placed in the respective housings and the device is then loaded in readiness.

Advantages and Disadvantages of This Device

At the outset it should be emphasized that this construction has been reduced to perhaps its simplest forms, resulting in a very useful and inexpensive arrangement possessing a number of well-worthwhile advantages, yet also containing a few limitations, which it will repay considering for a short time.

Dealing first with the advantages; the design embodies a very common and well-used mechanical construction for obtaining angular movement to certain members from straight-line motion of another. In this present application one great advantage is that it is possible to operate a considerable number of insert holder sleeves from a single moving plate. In the case of multi-impression tools this obviously is of great utility.

Then also it should be noted that operation of a number of such sleeves can be effected efficiently regardless of their angle of inclination. In addition it is not necessary that each holder shall be inclined to the same extent.

The inserts need not be all of the same size as regards their length of diameter, or even shape, as the device can very simply be adapted with differently sized sleeve holders to match the respective insert components being handled. Here again the designer is afforded a very useful degree of flexibility.

As in the case of a previously mentioned similar pre-loading device, it is easily possible to provide for portions of the cavity within the left-hand face of the base plate so as to cover the use of ring-type inserts for instance.

Another advantage often put to considerable usefulness is to be found in the ability of the mechanism to operate a number of insert sleeves simultaneously, or, if preferred, the operation of some may be delayed slightly so as to permit some insert studs, etc., to be cleared before shedding the remaining sleeves. This will be accomplished, of course, by a widening of the elongated slots in which the actuating pins are to slide, in the case of those sleeves it is desired to retard.

Thus the sliding plate will then move away from the base plate a suitable distance before these sleeves are actuated.

It will be found that even in the case of a device incorporating numerous insert sleeve holders, operation will be very smooth, quick, and performed with a reasonable degree of accuracy.

Yet another important point is that no springs of any kind are employed in the construction, and, furthermore, that all the mechanism is plainly visible to the user, so that he is able very quickly to detect any fault, such as a broken actuating pin, or distorted sleeve holder, lack of lubricant, excessive accumulation of dirt, etc. These may appear very minor points of advantage yet their cumulative effects may make all the difference between smooth trouble-free running high-speed production, and the opposite kind.

It should be stressed that in the case of all such pre-loading devices the designer should aim at keeping the working parts as few as possible so as to keep the total weight of the article within reasonable limits. Production is likely to suffer very adversely if the pre-loader is of such massive proportions that two persons, say, are required to lift it into position. In the case of the mechanism under particular consideration it is easily possible to make this strong yet of light weight due to the fewness of working parts and general simplicity of construction.

Turning now to the disadvantages which are worthy of notice by both designer and maintenance engineer, it should be said that these are largely associated with the constructional principles and features involved rather than the design and operating methods.

Perhaps the main objection to be levelled against this construction is the difficulty which will be experienced in ensuring the continued accurate location of the insert-holding sleeves and, by them, the location of the insert components within the mould cavity.

Close examination of the illustration will show that the holder sleeves must always be correctly positioned otherwise their left-hand end faces may project or fall short of the end face of the base plate. Should this occur not only will the insert itself be wrongly situated, but undesirable flash or depression will be formed on the end of the finished moulded article.

It will have been noted that each sleeve is provided with a shoulder against which the base plate bears when sleeve is in its correct position. The base plate is suitably recessed at these points in order to form a square face to meet the shoulder. These points will have to be maintained scrupulously clean otherwise any dirt or thick lubricant, etc., trapped between shoulder and bottom of recess, will serve to prevent the sleeve from finding its correct location. The same conditions will result if the sliding plate becomes distorted from any cause as this will mean that only some of the sleeves will be held down against their recess seatings in base plate. Or if wear arises on the guide pillars and their sleeves a slight misalignment of the sliding plate may develop leading to the same unsatisfactory results.

Apart from this probable loss of accurate positioning of the sleeves and their inserts from the above causes, perhaps an even greater liability to error will come from the method of attaching the sleeves to the projection strip of the sliding plate. With cylindrical pins sliding in elongated slots of the kind illustrated wear of one or both members is almost sure to develop before a long production run has been completed due to the prolonged sliding friction created by the connections. This will mean that when the mould has been closed and the injection shot made, the sleeves and inserts may be forcibly pushed backwards an amount equal to the extent of slackness resulting from any wear between the actuating pins and their slots.

So that in the case of a mould having to produce very large quantities it will be advisable to improve this method of connection so as to minimize the possibility of wear. This may easily be performed,

however, by simply widening the elongated parallel slots sufficiently to receive a close-fitting phosphor-bronze slider block, through which a hole is drilled to take the actuating pin. In this manner the friction pressure will be distributed over a much larger area, and also the most advantageous non-frictional metals can be employed. In the event of any wear occurring it is a very easy matter to replace these anti-friction blocks for new and close-fitting ones.

Yet another drawback likely to prove a source of trouble, after the pre-loading device has been used for an appreciable time, refers to the tendency of the seating holes in the insert sleeves to wear along their sides and particularly at their mouth portions. This will largely be due to the repeated action of admitting and withdrawing the inserts themselves. This, of course, will mean that after a time the inserts will no longer be held smartly within the sleeves, or, indeed, very accurately either, and as a result they will be prone to disturbance when a freshly loaded plate is being placed in position.

Various simple yet effective arrangements can be employed to prevent this condition becoming serious, but unfortunately space forbids making anything more than the briefest mention of one or two methods. In the case of the present mould design and the illustrated preloaded feeder, the circumference of the sleeve holders could be provided with an annular groove deepened very much at one side so as to break through into the seating hole. Inserted into this groove would be a split-ring-type spring of D shape, so located that its flat side fitted into the deep portion of groove sufficiently to bear lightly upon the insert shank within. Thus a light spring pressure would be maintained on the insert shank adequate for holding it in its proper place. The groove would have to be located well away from end of sleeve, and made deep enough at all points to allow the spring ring to nest within, without causing interference with the free sliding action of the sleeve in the base plate.

In other forms of mould construction, especially where the end faces of the insert sleeves do not lie contiguous with the cavity opening as in the illustration at Fig. 1, the sleeves themselves could very well be slotted for a portion of their length, then hardened and tempered and ground somewhat after the manner of an ordinary spring collet sleeve. It would be necessary to make the end portion of sleeve conical in shape, this to be fitted against a tapered recess in the base plate when the sleeve was moved to its proper moulding situation. Thus a spring pressure would then be imposed on the insert component during the act of injection.

Doubtless many other equally effective adaptations will be devised by the ingenious designer to overcome the aforementioned troubles.

It should also be noted that the guide holes in the base plate are not lined out with renewable bushings, which will mean that any wear due to the sliding to and fro of the insert holders will eventually result in slack fitting of same and resultant departure from correct angle of inclination, as well as the possibility of additional flash.

Notwithstanding all these disadvantages, the pre-loading mechanism should give effective service for a considerable time if given due care in use, and maintained clean, well lubricated, and frequently inspected to discern signs of wear, injury or other fault. The maintenance toolmaker should experience little trouble with the adapted forms of this mechanism as just suggested.

(To be continued)

AERO RESEARCH, LTD., BULLETIN

Bulletin No. 36 from Aero Research, Ltd., Duxford, Cambridge, has been received. It deals with veneer production for the manufacture of plywood in four sections: peeling or rotary cutting, slicing, half-round cutting and sawing. The subject matter is most interestingly described and provides an excellent groundwork for those who wish to carry out plywood production and the modern gluing techniques.

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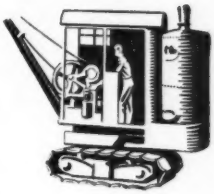

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ISSUED BY THE MINISTRY OF FUEL AND POWER

DECEMBER, 1945. Vol. IX. No. 103 **Plastics** ONE SHILLING & SIXPENCE

We suggest that the description 'Manufacturers of Modern Plastics Materials' might, for colloquial use, be streamlined down to 'Plasticians'—not only to distinguish the manufacturer of plastics *materials* from the manufacturer of plastics *goods* but to save breath. The tag 'Plasticians' is at all events applicable to Erinoid, since Erinoid are primarily technicians in the chemistry of plastics in their various forms. Thus it is more than a service of supply of plastics materials that Erinoid offer the plastics manufacturer . . . as plasticians we have unique experience upon which he may draw.

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